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Scientific Editor

Eugenia Smyrnova-Trybulska

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INTRODUCTION

The theme of the conference is: *“E-learning and STEM Education*”.
“Skills in Science, Technology, Engineering and Mathematics (STEM) are becoming an increasingly important part of basic literacy in today's knowledge economy. To keep Europe growing, we will need one million additional researchers by 2020.” (http://www.eun.org/focus-areas/stem)

The monograph *“**E-learning and STEM Education**”* includes articles based on the best papers prepared and presented by authors from nine European countries and from more than twenty universities during the 11th Annual International Scientific Conference ”**Theoretical and Practical Aspects of Distance Learning**”, subtitled: “***E-learning and STEM Education***”, which was held on 14-15 October 2019, organized by the Faculty of Ethnology and Sciences of Education in Cieszyn, University of Silesia in Katowice, Poland.

Experts on STEM and robotics in education from 10 countries, in particular Austria, Bulgaria, Czech Republic, Morocco, the Netherlands, Poland, Slovakia, Ukraine, Russia, Turkey reflect on how STEM education is currently viewed and implemented in their country, drawing on the legislation and funding focus and using local data to predict how the future will unfold for STEM education.

The speakers from the University of Innsbruck (Austria), University of Twente (the Netherlands), the Comenius University in Bratislava (Slovakia), Plovdiv University “Paisii Hilendarski” (Bulgaria), Borys Grinchenko Kyiv University (Ukraine), Gdańsk Technical University (Poland), Herzen State Pedagogical University of Russia, St. Petersburg (Russia), Jagiellonian University (Poland), Warsaw University (Poland), Silesian University in Opava (Czech Republic), Jesuit University of Philosophy and Education "Ignatianum", Cracow, (Poland), University of Silesia in Katowice (Poland), University of Defence in Brno (Czech Republic), K. Ushynskyi South Ukrainian National Pedagogical University (Ukraine), Maria Curie-Skłodowska University in Lublin (Poland), Lublin University of Technology (Poland), Mykhailo Drahomanov National Pedagogical University, Kyiv, (Ukraine), Kazimierz Wielki University in Bydgoszcz (Poland), Taras Shevchenko National University "Chernihiv Collegium" (Ukraine), Dniprovsk State Technical University (Ukraine), University of Ostrava (Czech Republic), Pedagogical University of Krakow (Poland), University of Social Sciences and Humanities in Warsaw (Poland), Makarenko Sumy State Pedagogical University (Ukraine), Poznań University of Medical Sciences (Poland), Ternopil

University (Ukraine), Kherson State University (Ukraine), Warsaw University of Technology(Poland), University of Social Sciences and Humanities in Warsaw (Poland), Izmail State University of Humanities (Ukraine), Adam Mickiewicz University in Poznań, (Poland), and other educational institutions delivered lectures providing insights into interesting studies, presented their recent research results and discussed their further scientific work.
The authors include experts, well-known scholars, young researchers, highly trained academic lecturers with long experience in the field of e-learning, PhD students, distance course developers, authors of multimedia teaching materials, designers of websites and educational sites.

I am convinced that this monograph will be an interesting and valuable publication, describing the theoretical, methodological and practical issues in the field of E-learning in STEM education offering proposals of solutions to certain important problems and showing the road to further work in this field, allowing exchange of experiences of scholars from various universities from many European countries and other countries of the world.

This book includes a sequence of responses to numerous questions that have not been answered yet. The papers of the authors included in the monograph are an attempt at providing such answers. The aspects and problems discussed in the materials include the following:

1. E-learning and STEM Education

- STEM education trends
- Robots and coding in education.
- Immersive learning environments. Blockchain.
- Internet of things. 3D printing

2. E-environment and Cyberspace

- E-environment of the University.
- SMART-Universities. SMART Technology in education
- E-learning in a sustainable society.

3. E-learning in the Development of Key and soft Competences:

- Effective development of teachers; skills in the area of ICT and e-learning
- Key competences in the knowledge society,
- Use of e-learning in improving the level of students' digital competences,
- Distance Learning and Lifelong Learning
- Self-learning based on Internet technology

4. E-learning and Intercultural Competences Development in Different Countries:

- Legal, social, human, scientific, technical aspects of distance learning and e-learning in different countries,
- Psychological and ethical aspects of distance learning and e-learning in different countries,
- Collaborative learning in e-learning,

5. E-learning Methodology – Implementation and Evaluation:

- European and national standards of e-learning quality evaluation,
- Evaluation of synchronous and asynchronous teaching and learning, methodology and good examples,
- MOOCs – methodology of design, conducting, implementation and evaluation,
- Contemporary trends in world education – globalization, internationalization, mobility.

6. ICT Tools – Effective Use in Education:

- Selected Web 2.0 and Web 3.0 technology,
- LMS, CMS, VSCR, SSA, CSA,
- Cloud computing environment, social media, Multimedia resources Video-tutorial design.

7. Alternative Methods, Forms and Techniques in Distance Learning:

- simulations, models in distance learning,
- networking, distance learning systems,
- m-learning.

8. Theoretical, Methodological Aspects of Distance Learning:

- Successful examples of e-learning,
- Distance learning in humanities and science,
- Quality of teaching, training programs and assessment,
- E-learning for the disabled.

Publishing this monograph is a good example of expanding and strengthening international cooperation. I am very grateful for valuable remarks and suggestions which contributed to the quality of the publication. Here I especially want to thank Ryszard Kalamarz, Andrzej Szczurek and Dominika Zegzuła for their assistance in editing this publication. Also, I would like to say 'thank you' to the authors for the preparation and permission to publish their articles. I wish all readers a pleasant read. Thank you.

Eugenia Smyrnova-Trybulska

CHAPTER I: E-LEARNING AND STEM EDUCATION IN DIGITAL SOCIETY

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ROBOTS AS FRIENDS, CO-WORKERS, TEACHERS AND LEARNING MACHINES – METAPHORICAL ANALYSES AND ETHICAL CONSIDERATIONS

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Abstract: *In the wake of digital networks and the penetration of private and public realms by algorithmic dynamics and robots, new claims and tech promises as related to A.I., robotics and machine learning have been increasingly gaining currency. On the one hand, new opportunities for individuals, groups, societies and transnational developments are being emphasized. On the other hand, there is a need of differentiated and critical analysis in view of grandiose promises, naive visions of robocracy and obvious examples of A.S. ("Artificial Stupidity"). The paper presents a selection of metaphorical descriptions of robots and human-robot relations, followed by an analysis of the key metaphor "artificial companion". On this basis, the relevance of the results for issues of accountability and responsibility is being presented. Finally, the contribution aims at reflecting ethical consequences for future-oriented ideas of responsible robotics.*

Keywords: educational robotics, artificial companions, metaphor analysis, robot ethics, machine learning

INTRODUCTION

From ancient music machines and wind-powered organs designed by Hero of Alexandria (ca. 10-70 C.E.) to Vaucanson's automatic duck, and from Čapek's (2004) play *Rossum's Universal Robots (RUR)* to autonomous robots, chatbots and molecular machines that act flexibly, metaphors play an important role in the history of human-machine interaction. Throughout history, a wide range of imaginary worlds regarding automated interaction, imagination of mediated communication and technological "wish worlds" (*Wunschwelten*) (Stadelmann et al., 2000) have been described. However, the idea of robots as "machine humans" or autonomous machine beings that are created by humans and by means of science and technology did not develop until modern times (Gendolla, 1980).

In cultural theory, social sciences and philosophy, various media-cultural, socio-technical and ethical aspects at the interfaces of technological, cultural, economic, social and political developments are being researched, usually starting from the assumption that complex entanglements of these developments are setting the direction and pace of societal developments rather than robotics, information technology or A.I. itself. In technological discourses, on the other hand, distinctions between different robot types, technical aspects and application contexts are of primary importance. The classification of robots, for example, is often made by distinguishing between environments and mechanisms of interaction and especially by application fields (Ben-Ari & Mondada, 2018, p. 2f). Typically, industrial robots, social humanoid robots, social bots, chatbots and nanorobots or molecular machines are regarded as parts of different worlds based on different technologies.

However, these complex worlds are conceptualized, there is the problem of how they are connected and communicated in cultural and societal contexts. Among the connecting elements, binding forces and mediating structures we can find scientific achievements including mathematical constructions, technological and cultural developments enabling the production and programming of different types of robots, constellations of hegemonic or leadership interests, hopes and technological promises regarding future developments, discursive relations and narration patterns, and last but not least, metaphors.

The research questions of the study include:

- What are typical examples of metaphorical descriptions of robots and human-robot relations?
- How can the key metaphor of the "artificial companion" be analyzed?

Furthermore, the paper explores the relevance of the results for corresponding issues of accountability and responsibility. Finally, the contribution aims at reflecting ethical consequences for future-oriented ideas of responsible robotics.

1. METHODOLOGY OF METAPHOR ANALYSIS

Even though methodological approaches in metaphor analysis do not yet play a central role in research in the humanities, cultural studies and social sciences, their importance should not be underestimated. The relevance of methods of metaphor analysis goes far beyond the textual interpretation of metaphorical phrases and investigation of underlying patterns of imagination and perception. The spectrum ranges from the analysis of practical uses of metaphors in everyday life to philosophical investigations of ways of constructing realities.

1.1. From Ancient Traditions to Recent Developments

Metaphor is as old as historical records. As for European traditions, there is a variety of forms dealing with metaphorical expressions including Homer's *similes,* Isocrates' *metaphora* and Plato's *metapherein* ("transfer") and *onomata* ("transferring words") (Kirby, 1997). To this day, countless contributions to philosophy and the methodology of metaphor analysis refer to Aristotle, who defined metaphor as "the application of a strange (alien, *allotrios*) term either transferred (displaced, *epiphora*) from the genus and applied to the species or from the species and applied to the genus, or from one species to another, or else by analogy" (Aristotle, 1982, 1447b; italics in orig.). Aristotle's four possibilities of creating a metaphor – genus to species, species to genus, species to species, and by analogy or proportion and resemblance – show a social and political dimension in so far as the major goal of rhetorical speech is persuasion, which is of importance in many present-day contexts of digital communication, too.

However, goals and characteristics of metaphorical analysis depend on what is seen as a metaphor, how they are conceptualized and as what metaphors are being seen or taken. According to Niedermair (2001, p. 144), a metaphor can be a "linguistic expression, a concept, an image, a software surface, an affect, an emotion, a scheme – or anything and everything". Then again, metaphors can be seen as "jewellery and ornament, as improper manner of speaking, as falsification of truth, as subversive disruptive factor, as Trojan horse, as profound manipulation, as sign of creativity, as strategy of change – or as principle of the construction of reality in general" (Niedermair, 2001, p. 144).

From a conceptual perspective, an enormous variety of characterizations and conceptualizations can be distinguished. Among all of those numerous options and relevant distinctions, the following are especially important from a systematic perspective:

- Blumenberg's philosophy of metaphors and his take on the use of metaphors
  as a "narrow special case of non-conception [*Unbegrifflichkeit*]" in the "fore-field of concept formation" (Blumenberg, 1993, p. 77).
- Goodman's (1968) distinction of literal and metaphorical exemplifications.
- "The essence of metaphor is understanding and experiencing one kind of thing in terms of another" (Lakoff & Johnson, 1980, p. 5) and further developments in cognitive linguistics from experientialism to embodied realism (Lakoff & Johnson, 1999).

- Glaserfeld’s (2005) take on metaphors as indirect descriptions.
- Krippendorff’s definition of metaphors as “linguistic vehicles through which something new is constructed” (Krippendorff, 2009, p. 51).
- The importance of contexts, the role of context-induced creativity and further extensions of conceptual metaphor theory as outlined by Kövecses (2009).
- The relevance of context disruptions and contextual entanglements regarding epistemological dimensions as argued by Gehring (2010).

The list could easily be continued. The methodology used in this study is outlined below.

1.2. From Philosophical and Linguistic Analysis to Qualitative Research

Among the manifold conceptual and methodological developments in metaphor analysis, we find strands of development from semantics to pragmatics in linguistics as well as further developments in social sciences (Niedermair, 2001, p. 147-155). In educational research, too, there are examples of theoretical studies of metaphors (see, for example de Haan, 1991; Drerup, 2016) as well as of empirical studies (see, for example Guski, 2007; Gansen, 2010).

On the assumption that constructivist perspectives of methodology (Moser, 2011) open up fruitful ways of connecting theoretical and empirical concerns in a non-fundamentalist manner, metaphors are taken hereafter as situated products of interaction in social and media-cultural contexts. As for the methodical procedure, the explorative study combines elements of Niedermair’s (2001) approach to metaphor analysis with the qualitative research methodology elaborated by Schmitt (2011, 2017) and Schmitt et al. (2018).

As far as details are concerned, the following steps are intended:

- Specification of the material.
- Explication of research questions.
- Collection and reformulation of metaphorical expressions.
- Bundling metaphorical concepts and central motifs.
- Interpretation and integration in argumentation context.

The third step deals with the collection and reformulation of the metaphorical expressions occurring in the selected corpus of material, as well as the corresponding indication of focus and frame (Black, 1954). In doing so, metaphorical concepts in the sense of “prototypes” (Buchholz, 1996), “root metaphors” (Schmitt et al., 2018, p. 31) or “key metaphors” (Schachtner, 1999) can be reconstructed (see also Niedermair, 2001, p. 159). Furthermore, questions of enlightening and obscuring perspectives are of importance.

In this explorative study, a selection of typical examples of metaphorical descriptions of robots and human-robot relations as well as an analysis of the key metaphor of "artificial companion" are presented for discussion.

2. ANALYSIS OF ROBOT METAPHORS

Today, we find a variety of metaphorical descriptions of robots in contexts of industrial production, generic and mobile applications, entertainment and science fiction as well as research and development. The spectrum extends from slaves to friends, and from autonomous devices to learning machines. Inversely, the term 'robot' is sometimes used as a metaphor, too, for example for 'the inhuman', 'the other', 'the alien', 'the strange' or 'the rational'. The examples outlined below refer to fields of education and learning as well as social work and care.

2.1. Exemplary Robot Metaphors in Education and Care

In the course of the preliminary study, material has been specified and selected as related to the fields of education and care that provides prototypical robot metaphors. Typical examples of metaphorical descriptions of robots and human-robot relations refer to robots as teachers, coaches, tutors, friends, co-workers, companions, nurses, conversation partners, comforters and guardians. Technically speaking, most of these kinds of robots fall into the category of "service robots."

From the perspective of metaphor analysis, frame and focus (or source and target) can be explicitly described as shown in Table 1.

Table 1.

Exemplary robot metaphors

Selected Quotations	Focus	Frame
"It looks just like an ordinary NAO robot, but the heart and brain of Elias is the robot behavior developed by Utelias. It can understand students' needs and help them practice their speaking skills in a fun and save [sic] environment, without fear of making mistakes. Combined with Elias application, the robot can turn your classroom into a positive learning experience, filled with engaging content and happy students. Get ready to take learning to a whole new dimension with Elias!" (Utelias Technologies, 2019)	NAO-robot (Elias)	language coach, help, understand needs, promote positive learning experiences in classrooms
"A robot can make a shy kid talk, motivate the child who is not interested about studying, or having any conversations… A robot can be a teacher when there	NAO-robot (Elias)	have conversa-tions, motivate uninterested

are not enough qualified teachers; a robot never gets tired, just keeps on repeating or listening, whatever you need. It understands your needs and makes the learning miracle possible. Is it a science fiction dream, or something we are now starting to understand and accept as a reality? The robot revolution has started. That has happened for sure. There already are hotels that are driven by humanoid robots, elderly homes where NAO robots help stimulate patients with dementia, and dentist receptions where NAO robots talk with kids so that they forget to be scared. **This is reality in modern era: Robots are integrating with our everyday life.**" (Pääkkönen, 2018; bold in orig.)		children, teacher, help, talk, understand needs, enable learning miracles
"Our mid-term vision is to purposefully and responsibly promote this new generation of *robonatives* with suitable educational concepts. The main goal is to enable them to use and further develop state-of-the-art robotic technology, create benefits for their own lives and careers and in turn help to shape our future society." (Haddadin et al., 2019, p. 4, italics in orig.)	current generation of children	digital natives, robotic natives, create benefits, shape future society
"Like a good nurse, the robot can continuously observe and monitor the activities of the user. In a long-term view, this allows to provide valuable data for a long-term assessment and to detect changes in behaviour that might indicate a decline in the overall health state, e.g. reduced mobility. On a daily basis, the robot can be the personal coach of the user, detecting e.g. that there have been only pretty limited physical activities this day and encouraging to do some training." (Meyer et al., 2009, p. 4)	robot (Florence)	observe and monitor, provide data for long-term assessment and to detect behavioral changes, personal coach, detector, encouragement
"In the GUARDIAN ANGELS project the functionality is not incorporated in a robot but in a series of wearable devices. The main function of these devices is to monitor physical and physiological parameters of the user and his or her environment (e.g. blood pressure, hydration level, stress, air quality, information for blind persons). These computational devices are permanently in operation but remain invisible in the background, hence guardian angels. GUARDIAN ANGELS are companions in the broad metaphorical sense as 'invisible helpers' continuously accompanying the user." (Böhle & Bopp, 2014, p. 163)	computational wearable devices	invisible helpers, monitors, companions, guardian angels

"Assistants are helpers providing *personal assistive services*. In contrast to Guardians the user is enabled by an Assistant to fulfil tasks, which she or he would otherwise be unable to perform. The emphasis of these companions is not on supervision but on enabling. [...] 'The robot is not only considered as a ready-made device but as an artificial creature, which improves its capabilities in a continuous process of acquiring new knowledge and skills' (COGNIRON Appendix III)." (Böhle & Bopp, 2014, p. 163; italics in orig.)	robot	assistant, companion, enabler, learning creature able to acquire new knowledge and skills
"The social robot is imperfect by design and behaves more like a clumsy dog than a perfect butler or servant. With this approach the acceptance of robot assistances shall be increased. The concept of co-learning assumes that the robot and the user are providing mutual assistance. The user shall not be dominated by the technology, but empowered, physically, cognitively and socially (ACCOMPANY Appendix III)." (Böhle & Bopp, 2014, p. 164)	social robot	clumsy dog vs. perfect butler or servant, co-learning, mutual care, empowerment
"This creates the hope and, at the same time, the fear that robots will be integrated into our society as full-fledged actors in the future." (Weiss, 2012, p. 430, translation by T.H.)	animal(like) robot	socially integrated, full-fledged actor

Source: Own work

This collection already shows that the metaphorical ways of describing activities, potentials and features of robots and human-robot relations are consistently accompanied by far-reaching announcements, claims and more or less cautious assertions. An in-depth analysis of an integrative metaphorical concept will show that such forms of such descriptions not only support bridging technical and cultural codes but also have misleading features.

2.2. "Artificial Companion" – Analyzing a Metaphorical Concept

2.2.1. Ambivalent Perspectives

"Artificial companion" has been chosen for this in-depth analysis because the metaphor functions as a meta-metaphor and as an integrative metaphorical concept. It can be used on its own and also as including or related to other metaphors. In both respects, it shows orienting as well as disorienting characteristics.

Table 2.

"Artificial Companion" as an integrative metaphorical concept

"Artificial Companion"	Focus	Frame

as an Integrative Metaphorical Concept		
"Companions, comrades, helpers in need, consultants, protectors, guardians, guardian angels, support in everyday life, good friend, best mate, counselor, other half, lover, buddy ... - Artificial Companions are not only for us, but also in the interdisciplinary field of Service Robotics, Artificial Intelligence and Human Computer Interaction a metaphor rich in associations, even more so: The metaphor is a guiding vision for all those working here in research and development." (Pfadenhauer, 2018, p. 57; translation by T.H.)	robots	accompany, monitor, protect, advise, good friend, guardian angel, lover, guiding vision, etc.

Source: Own work

Bundling metaphorical concepts and the analysis of central motifs reveals some relevant points. "Artificial companion" as a widespread integrative concept refers to:

– fulfilment long-lasting dreams of technologies serving humans,
– suggestions of professional support as well as reliable companionship,
– viable and meaningful human-machine relations,
– notions of machines "learning" and "acting" as trustworthy and rational assistants,
– accounts of crucial relevance for multiple functions in various social and cultural respects,
– flexibility towards "common sense" and research contexts generally,
– mediation of positive moods as well as positive attitudes towards emotional
ties and affective bonds with machines, at the same time mollifying gestures towards "automation anxiety",
– enhanced embodiment of automated routines and external objects,
– a vision of technological solutions for psycho-social and educational issues.

Furthermore, perspectives that are highlighted or opened can be summarized as follows:

– technological advancements in relation to personalized, adaptive, "learning" systems,
– functional responsibility of various interdisciplinary IT fields for fields like education, nursing and social care,

- claims to leadership as regards primarily relevant approaches to dealing with problems in caring, assisting, welfare, education, relationship dynamics, etc.,
- humanly adequate structuring of relationships and modes of companionship with prospects of both sustainable solutions and large profits,
- new potentials for IT businesses in view of emerging technologies and changing media-cultural constellations,
- possibilities of fruitful interactions of semi-autonomous humans and machines,
- solution-oriented working and acting open to inter- and transdisciplinary approaches,
- demands for the promotion of computational thinking,
- alternatives to former welfare-state measures in terms of technological and market-economy reforms over the medium term.

On the other hand, there are also perspectives that are concealed or obscured. Among them we find:

- *pars pro toto* descriptions, restricted wordings and tunnel visions,
- misleading rhetoric, especially regarding issues of responsibility and accountability,
- primacy of industrial and political interests in rich countries,
- huge research funding, business models and commercial exploitation of data,
- limitations of voluntary participation when making use of services provided
  by artificial companions,
- leeway for multiple forms of empowerment and fostering self-responsibility,
- interplay of (partially unconscious) drivers for excessive and constant monitoring, control, surveillance, compliance and enforcement,
- path dependency of developments – alternative options for development,
- limitations of computability and predictability of complex phenomena and respective developments.

As we can see, perspectives are ambivalent. Some have enlightening features while others are concealing relevant dimensions and aspects.

2.2.2. “Artificial Companion” – An Interpretation

The instantaneous character of the integrative metaphorical concept may support superficial uses of the term and the concealment of ambivalent perspectives. However, analysis has shown its ambivalent character. Undoubtedly, it features multiple connectivity regarding a variety of metaphors, languages, contexts of application and forms of use in technical, political and socio-cultural spheres. Thereby, the metaphorical concept fosters discursive integrability including affirmative and critical perspectives.

Moreover, “artificial companion” alludes to long-lasting dreams of technologies serving humans in intelligent, sensitive, contextual and responsible ways, now for many if not for “everybody” (right now or in the near future). The metaphor suggests responsibility and agency as well as human-like social, emotional and moral intelligence. It also creates expectations of empathic human-like educational or care processes as well as “warm friendship” and company – in contrast to the previous “cold care” of machines. It involves prospects of uncomplicated relationships and pragmatic solutions regarding human needs and necessities combining humanity, human dignity and versatile functionality.

Finally, it addresses positive views on “digital inclusion” as well as social and socio-technical cohesion in view of a lack of solidarity among humans. From a methodological perspective, “artificial companion” does not only work as “conceptual metaphor” or as “(dis-)orientational metaphor” but also as “visual metaphor” (Kövecses, 2019) and as “transcoding metaphor” (van den Boomen, 2014).

3. BETWEEN THE PRIORITIES OF RESPONSE-ABILITY AND RESPONSIBILITY – DISCUSSION

Further research may show how interactive dimensions related to various contexts of usage of metaphorical concepts like “artificial companion” and similar metaphors deal with the ambivalent characteristics that have been outlined above. However, there are ethical and normative dimensions beyond efforts of bridging empirical research and hermeneutic interpretation or linguistic analysis.

The promotion of metaphors like “artificial companion” and corresponding socio-technical systems tend to ignore paradoxical aspects and complex constellations at the crossroads of increased response-ability and the many dimensions of responsibility (Lenk, 1994; Kirchschläger, 2014; DEDA, 2017; Renda, 2019). In this context, we should not underestimate the emergence of new responsibility gaps in addition to former gaps (Matthias, 2004). This is not only due to the complexity of entangled dimensions and intertwined developments of socio-technical systems, autonomous devices and “smart” interactive systems. This is also due to widespread suggestions of innovation pathways without any alternative (Mansell, 2018) and well-known tendencies in big industries to privatize economic profits and to collectivize costs for damages and undesirable side effects.

Ways of speaking about autonomy are manifold. They refer to decision-making abilities of subjects and the principle of human autonomy but also, for example, to the autonomy of art, schools, universities, parties, companies and to self-government in view of social, economic or political pressure toward conformity. If robots are described without restriction as intelligent autonomous systems equipped with sensors, then they should be able to pass a Kant test in order to show autonomous decision-making abilities. Leschke (2018) has recently introduced this consideration:

"Kant's notion of the subject, however, goes far beyond both the utilitarian quantification strategy and the Turing test, in that he not only makes the somewhat arbitrary perceptibility as subject a condition, but at the same time formulates the categorical imperative as a kind of test question, on which possible differences and thus the differentiation of prostheses and subjects could prove themselves." (Leschke, 2018, p. 92; translation by T.H.)

Obviously, this not about an *a priori* control system based on normative constructions and programmed decision structures for "moral machines". It is about the *universalizability* of decisions. Accordingly, the relevant distinguishing feature between autonomous and non-autonomous systems is the ability to universalize decisions.

"Only if a person or a system is able to universalize its decisions is it a subject or an autonomous system. The Kant test, which in some measure assesses the rational capacity of the subject or the automatic system, distinguishes between systems that can act autonomously, i.e. without control, and those that in any case require control by an autonomous subject." (Leschke, 2018, p. 93; translation by T.H.)

As we can see, a Kant test would go beyond a classic Turing test. If we assume that this kind of self-regulatory capability at the level of universalization is possible, we should also consider abilities of thinking and learning. No matter if we talk about self-learning robots teaching kids or adults, or if we reflect on social bots or chatbots based on A.I. and machine learning features, similar issues require differentiated analysis and prudent discussion. Definitions like the following one call for interdisciplinary approaches, discursive contextualization and the drawing of learning-theoretical distinctions rather than for agreement without further ado:

"Machine Learning is the science of getting computers to learn and act like humans do, and improve their learning over time in autonomous fashion, by feeding them data and information in the form of observations and real-world interactions." (Faggella, 2019)

Whether learning refers to changes of behaviour, attitudes, values, mental abilities, task performance, cognitive structures, emotional reactions, action patterns or social dynamics, in all cases the phrase “like humans do” calls for a closer examination and differentiated analysis. The same applies to different conceptualizations of learning, for example as process of building up and organizing knowledge, as process of transformation based on processes of meaning-making in specific contexts, or as process enabling or leading to relative permanent capacity change beyond “pure” biological maturation or aging. Blurs between programmed forms of domain-specific autonomy and profound forms of trans-contextual autonomy, between determinism and predictability, and between various forms of “automatism” (Bublitz et al., 2010) should also be reflected and not just celebrated.

There is much to suggest that the ascription of anthropomorphic characteristics to robots, like responsibility, autonomy, agency, intentional reasoning, or human-like social, emotional and moral intelligence, is rather in line with business strategists and vague notions of (market) accountability than with differentiated analyses in research on responsibility or robot ethics (Capurro et al., 2006; Lin et al., 2014; Tzafestas, 2016; Heidbrink et al., 2017). In view of many misleading or problematic naming practices in contexts of describing and dealing with robots it seems to be appropriate to consider new names for a “species” with “mind-less morality”, “pure” machines and biological-computational hybrids (Floridi & Sanders, 2004).

CONCLUSION

Developments in robotics and A.I. have enormous transformative potential in industrial, socio-cultural, economic and educational contexts as well as in everyday life. However, assessments of its manifold strengths, weaknesses, opportunities and threats (SWOT) fall short if these are based on a technological determinism. It is not digital technologies alone that determine societal, economic, social, cultural and ultimately also digital transformation processes and corresponding trends. Transformative dynamics emerge at the interfaces of technological, societal, media-cultural, economic, political and juridical dynamics.

In the complex web of these r/evolutionary developmental dynamics, metaphors play a significant role among other connecting, binding, (dis-)integrating and sometimes disrupting forces like hegemonic aspirations, economic interests or unconscious desires. Embedded in narrative structures and multimodal forms of communication, they show mediating functions and enable communication across discursive, technical (*fachsprachlich*) and cultural borders.

Translational usability and transdisciplinary “revolving door” effects of metaphors, however, show ambivalent traits. On the one hand, the usage of terms like ‘teacher’, ‘coach’, ‘tutor’, ‘friend’, ‘companion’ or ‘conversation partner’ as metaphors for robots and human-robot relations sheds light on innovative possibilities for development and design. On the other hand, such forms of use also conceal problematic aspects worthy of discussion. The attribution of human characteristics such as ‘autonomous’, self-learning, ‘creative’, ‘conversational’, ‘intelligent’, ‘moral’ or ‘smart’ to programmed and sensor-equipped automatons is undoubtedly useful for marketing purposes. On closer examination, such attributions turn out to be problematic, especially if ‘intelligent’ systems and autonomously operating machines are attributed ethical reasoning and decision-making abilities, too.

So far, “artificial companions” would not be able to pass a Kant test. Accordingly, we should recognize the limits of technical solution capacities and be skeptical towards grandiose promises of technological salvation. Metaphor analysis can contribute to the exploration of viable development paths between the Scylla of empty robot-promises and the Charybdis of fictions of medial and technological innocence. In addition, systematic evaluation of socio-technical systems, circumspect technology assessment (*Technologiefolgenabschätzung*), thoughtful discourse assessment (*Diskursfolgenabschätzung)* and exploration of various (digital) innovation pathways are indispensable for successful developments considering human responsibility as well as increasing response-ability of robots.

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EDUCATIONAL TECHNOLOGIES FOR E-LEARNING AND STEM EDUCATION

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***Abstract**: At the outset of innovating Vocational Education and Training (VET), we ask ourselves: What directions of innovation look promising in terms of 'perceived needs' and 'meeting endemic values'. From the pure scientific point of view, operationalizing "Quality of Learning" is one of the hardest nuts to crack; Once listing all relevant dimensions of learning processes and outcomes, there is no end. Similarly, to listing qualities in fashion, gastronomy, music, every new trend in socio-economic era, brings its own new desires and ideologies.*

PREFACE

The list of quantifiers for qualities of learning: the speed of it, easiness for the student and the teacher, endurance of what is learnt, the depth of it, its flexibility, its authenticity, its pedagogical soundness, self-efficacy and ……. Indeed, the student's capacity to become a successful entrepreneur. For those Higher Education teachers who admit that entrepreneurship is key to future societies, there might still be hurdles before arriving at confirmation on how to nurture entrepreneurship: "Are there dependencies between pure knowledge, craftsmanship and entrepreneurial mindset?" First of all, as it implies that these two excel in its innovative effects. But also, as they pretend to be feasible candidates in terms of its adaption by Higher Education stakeholders (incl. the students and their potential clients, their business partners, etc.). The best way to label gamification and story-telling is "catalytical" to the ongoing evolution of Higher Education and its surrounding society. Gamification and Storytelling seem to be strong triggers for changing the school-culture in Higher Education towards breeding ground for young entrepreneurs. Is the traditional teacher-student paradigm in conflict with the entrepreneurial - oriented Higher Education? We think not; a large part of the entrepreneurial mindset relies on the apprentice's eagerness to learn from anybody who can demonstrate competencies that may lead to solutions for unexpected problems. However, this very 'transfer-paradigm' (from teacher to student), though very much needed, is not enough as students in a receptive attitude are slow and even averse to 'changing themselves'. The classical teaching-learning paradigm is that students are supposed to adapt in order to comply with the assessment criteria. In order to create a life-long entrepreneurial learner it is more the 'willingness to change oneself', in order to grow where your customers are going to. In this sense Entrepreneurial is more than adapting your competences; it is developing a sharp eye for 'what is needed by others' rather than obeying your superior. A good entrepreneur does not follow what his/her customers want now. It is a matter of narrating to your potential customer in order to create his/her need of tomorrow. Here is where gamification and nitrification come in: It helps students to open an additional mindset. The real job for us now is to find effective design rationales on how to weave gamification and storytelling in existing curricula. Rather than delivering hard-core recipes, we claim that teachers need to go through a set of experiences how gaming and telling opens additional genres for our mentor roles in entrepreneurial stages of Higher Education.

Three main questions were posed. The essentials have been formulated below.
The three main questions are:

A. From your current good practices, does the choice for PBL (Problem-Based Learning) as a framework for gaming, storytelling and simulations look as an appropriate one?

B. What do you see as the most important steps to be undertaken before PBL can be integrated in courses throughout your organization?

C. What additional elements would you like to be articulated sharper in the years to come?

Experts' responses to the three main questions can be found below. Its overall tendency is that the techniques like storytelling, gamification, creative problem solving and problem-based learning have been already recognized as valuable ingredients of instruction and students' project work. Most of the teachers do not see them as obligatory formats for vocational education, however, firstly, the subject matter, secondly, the students' stage of socio-/cognitive skills and thirdly, development and fourthly, the mentor's actual pragmatic preferences should have a need for them in that particular situation. This overall conclusion leads us to the common-sense criterion of "fit for purpose"; It implies that the diversity of learning/teaching processes needs diversity in applied methods and tools as well. Throughout recent research it has been admitted that the proposed new methods/tools need to be integrated as candidate ingredients in an overall instructional design approach as generally endemic to Higher Education in general.

Keywords: Educational Technologies, E-Learning, Virtual Reality, Immersion, STEM Education.

INTRODUCTION

Entrepreneurship is the core target for future Higher education. As will be elaborated further in this article, entrepreneurial-oriented learning is as multi-facetted as business itself. However, it is worth to see a common denominator of an "entrepreneurial mindset" that may serve as a more generic driver for Higher Education and even for middle and higher education in general. In order to make the entrepreneurial-oriented Higher Education tangible, a subset of the recent didactic repertoire will be highlighted. There are many avenues for innovating Higher Education that have not been fully exploited yet: 1. Gamification, 2. Playing, 3. Collaborative Learning, 4. Storytelling and 5. Simulations are just the most obvious ones. However, also Mobile Learning, Virtual Reality and the many more techno-driven innovations to come are essentially promising candidates for the future of Higher Education. In order to make learning in Higher Education more effective, efficient and sustainable we need a strong foundation for its embedding in the actual educational situations and further consolidation. Having seen the recent scientific literature and good practice examples, this envelope is PBL (Problem-Based Learning): The method to place the apprentice at the very core of his/her learning process; (s)he (re)gains full ownership of the start of a life-long learning process. For the sake of innovative Higher Education it means that apprentices who typically have a less favourable earlier school experience, they need to be encouraged by being welcomed and empowered through a student-centred pedagogy. Problem-Based Learning should not be confused by Project-Based Learning. The essence of the PBL approach is to learn about a subject through the experience of solving open-ended problems found in trigger material; prototypical questions that orient the learner towards understanding what PBL questions ideally are. The PBL process does not focus on problem solving with a defined solution, but it allows for the development of other desirable skills and attributes. This includes knowledge acquisition, enhanced group collaboration and communication. As overall recommendation: Motivate Higher Education trainers to see the elegance and sustainability of PBL; (Smyrnova-Trybulska et al., 2017). It is a powerful paradigm before adopting and integrating the new ICT-based tools as presented before. The main driver behind the integration of PBL in Higher Education is that it fit very well with the type of motivation of young apprentices "to make a difference" and "find a job" or "start a company". More in general, we see a recent policy towards preparing Higher Education students for "Smart Jobs"; (Issa et al., 2017). It preludes a more active learning approach and ready for the post-industrial era where men and machine face new complementary skills and autonomous life-long learning. This inherent trend not only holds for including ICT skills; it is a much more intricate shift from technical-, via communicative- to conceptual skills. According to "Balance-Careers" the Top-Five conceptual skills are: Analysis, Communication, Creative Thinking, Leadership and Problem-Solving. According to "Business-Directory," conceptual skills can be delineated as: The ability to think creatively about, analyse and understand complicated and abstract ideas. Using a well-developed conceptual skill set, top level business managers need to be able to look at their company as a holistic entity, to see the interrelationships between its divisions, and to understand how the firm fits into and affects its overall environment. Until very recently these 'conceptual skills' were supposed to belong to the repertoire of corporate leaders and top managers. We see now that very rapidly these skills are seen as essential for labour force throughout the enterprise pyramid.

1. GAMING ELEMENTS IN EDUCATION

Before exploring the potential of Gaming and Storytelling it is useful to provide two main reasons for our searching in the next directions. The first is that, complementary to our day-to-day classroom efforts for converting students into better learners, the main question is to make educational systems better by rephrasing Kenneth Dunn (Kaufman et.al. 1997): "If students don't learn the way we teach them, let's teach them the way they learn". The second one is the notion that Higher Education faces a moving target; enterprises and economies are shifting due to globalization and new technologies. The third direction is that employees face more and more demand for strategic thinking. Though the term "conceptual skills" may suggest that it belongs to high level managers, there is a growing understanding that for a large class of jobs conceptual thinking is needed in order to promote problem solving and creative approaches. This trend goes together with the growing need for knowledge - rather than industrial workers. Conceptual skills are the next step after we mastered factual and procedural knowledge. Both knowledge and skills are consolidations after good practice has found an optimum;

As our surrounding world evolves, new Higher Education needs to be developed: Its goal is to prevent a group of youngsters to become obsolete. We hope to illustrate that gamification, storytelling and many more are indispensable in this continuous process. **Definition**: Gamification is the application of game-design elements and game principles in non-game contexts (Werbach, 2014). The main reason for defining gamification as a process is that it provides a scale for gamification and not an absolute category. Gamification commonly employs game design elements to improve user engagement, organizational productivity, flow, learning, employee recruitment and evaluation, physical exercise, traffic violations, voter apathy, and more. Werbach and Hunter (2015) identified five game dynamics used in gamification:

- **Constraints** are about balancing limitations and freedom for a player as well as integrating forced trade-offs in the design of a gamified solution.
- **Emotions** aim to produce enduring player engagement and appear during an activity.
- **Narrative** is represented for a player through either an explicit or implicit storyline having its own consistent inner logic and following a certain context.
- **Progression** reports the player's growth and development when navigating through a game and the possibilities to do so.
- **Relationships** consider the social interactions of players in a game which can create feelings of camaraderie, status and altruism.

A number of studies on gamification show that it has positive effects on individuals in terms of cognitive flexibility, changing role perspectives, etc. However, individual and contextual differences exist. Gamification can improve an individual's ability to comprehend digital content and understand a certain area of study such as music. Research into the use of gaming for learning shows that gamification penetrates all sectors of life where awareness, latent ambitions and mental growth are at stake. As such, gaming may not only increase the effectiveness of traditional learning goals like memorization and skill routinization; It may help learners to refresh their concept of what learning is about. In its deepest sense, learning can be seen as one's developing willingness to change him/herself; (Kommers, 2004). The contrast between single- versus double-loop learning is that single-loop learning can be compared with a thermostat that learns to switch-off the heating when a certain temperature is reached, whereas double-loop learning occurs when a device (or a person) learns to monitor a wide set of parameters and becomes keen on which of them are the best first-order predictors for anticipation when heating or cooling is needed. Games as we typically know for increasing speed and precision have already proven its value for learning. Its overall metaphor is "beat your peer student or your own score in the past". Double-loop learning games place the learner at the core of a realistic situation and ask to discover 'hidden' relationships in a certain domain. Where gaming aims at winning, playing aims at conquering new levels of understanding, self-awareness and self-efficacy. In terms of VET, it is the learner who attempts to become his/her own coach.

The relations Learning-Working and Playing-Working have been extensively explored in educational practice before. The intersection Playing-Working seems to be underexploited yet; See Figure 1. Its goal is to make apprentices better new colleagues who dare to question and help to transform into new business models. As Steve Jobs claimed: "Traditionally we, as Apple, scout and hire the best people around the globe, pay them highest fees, and subsequently tell them what to do..."; It reflects the growing notion that in the post-industrial era, working is the efforts to exceed earlier expectations and survive in an ever more competitive market. The notion of ‘double-loop’ learning confirms the manifold efforts in the last four decades to equip the learner with ever more autonomy, self-regulation and metacognition, in order to start the process of a life-long learning attitude as early as possible.

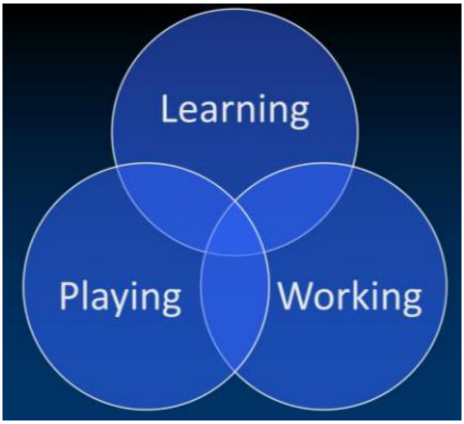

Figure 1: Synergy between Learning, Working and Playing.
Source: Bonanno & Kommers, 2008

2. WHY PLAY-BASED LEARNING? METHODOLOGIES AND APPROACH

Play-based learning as a research topic has been presented as a method for pre-school learning mainly. In this IO5 an effort is made to position the playing-working combination as a new prospect for VET. In the triangle learning-playing-working the phase of learning is traditionally seen as mitigation between work and play, in which play is unnecessarily seen as ‘leisure time’, ‘divertissement’ and ‘digression’. The essence of playing is the immediacy between actual interest, affordance and try-out. There is no other agenda than “follow your interest” and “see how far you can go”. So, though the improvisation and impulsiveness may look as “unfocussed” and “senseless”, the optimal sense-making occurs in the playing attitude as it completely absorbs the person. In terms of the net learning (understanding a complex of variables through experiencing direct-and indirect side effects of an earlier intervention) one can say that playing is one of the very few activities with a minimal of cognitive overload; no prescriptive agenda, no extrinsic motivations and a one-to-one match between cognitive repertoire and intuitive horizon. Just like virtual and vicarious allow the learning to take freedom and fully focus on the proximate zone of achievement, so is a situation of playing the de-facto match between momentary intention, imagination and cognitive operation. It is now a matter of finding complementary arrangements for Higher Education mentors to convey such a process and find adequate scenarios for progressively integrating its learning outcomes in meaningful segments of the job performance.

3. GAMIFICATION OF LEARNING: PRINCIPLES AND MECHANISMS FOR ENGAGEMENT

Gamification of learning is a much broader process than finding appropriate game templates and integrate them in curricular and instructional contexts. One of the recent efforts has been to classify better what element of gaming would contribute to the learning process. The prefix “serious” has been chosen to narrow the spectrum of diverse gaming genres. Critics came along that gaming for the gamer is always a serious matter. On the other hand game ambassadors claim that an explicit serious connotation may squeeze out the attraction of game-experience soon.

1. One of the drivers of game-based learning is Engagement; Learners feel immersed and sometimes even obsessed while playing in a virtual reality where a certain number of performance parameters are continuously measured and displayed.
2. The second driver is Flow; Its effects increase the learners’ strength of experience, concentration and endurance. In particular, for VET, gamification in learning has the extra effect of “Breaking the Yoke of Seriousness”; As “Work” is inextricably bound to serious business, the novice might easily get too much infatuated with “avoiding mistakes” so that “risk avoidance” easily emerges and hampers mindset for learning and understanding.

4. DIGITAL STORYTELLING FOR LEARNING

Definition: Storytelling describes the social and cultural activity of sharing stories, sometimes with improvisation, theatrics, or embellishment. Every culture has its own stories or narratives, which are shared as a means of entertainment, education, cultural preservation or instilling moral values. Crucial elements of stories and storytelling include plot, characters and narrative point of view. The term "storytelling" can refer in a narrow sense specifically to oral storytelling and also in a looser sense to techniques used in other media to unfold or disclose the narrative of a story. Research into the use of story-telling for learning can be found here. Its main lessons are that both the teacher and the learner have larger repertoires of earlier experiences and imagination than we typically rely on. A story is an existential (how do I experience a certain fact or event?) rather than epistemic (how things are). The term ‘Digital’ storytelling reflects that the face-to-face format is powerful, however not necessarily the only one. For instance, the option of letting people build their stories on top of earlier stories by others, or even simultaneously build parallel stories have been explored in the “Woven Stories” project; Harviainen et al., 1999 and Nuutinen et al., 2010. Connected, interlinked stories are a good candidate to promote collaborative understanding and constructivist in addition to instruction-based learning. The revaluing of story-telling can partly be attributed to the earlier technical virtues of hyperlinking, compartmentalized paragraphs and hypertext as decontextualized information; (Kommers, 1988). Narrative methods for revitalizing teaching and learning can be seen as compensation for the step-by-step “cleaning” of rhetoric; definitional purity and the wish to make texts tractable had the price of losing episodic lines and losing the persona (the imagined concrete person who the listener/reader can identify with). Marketing campaigns have already picked up this need for ‘Personal Templates’. In tutorials and manuals, we see the trend to articulate “the user” of “the customer” as vignette character: a fictitious flat character who serves as a simplification of the manifold persons who the apprentice may meet in the near future. In terms of scaffolding, the initial simplification like posing the customer as ‘caricature’ first and allowing an increasing realism of the customer as a more complete person later, might be a good heuristic for the design and pacing of the narrative approach. Once the apprentice becomes involved in virtual presence, the avatar is a comfortable way to represent oneself without disclosing his/her identity. An epitome of narrative format is TED Talks, amongst the ones by Sir Ted Robinson have a major message on creativity for both regular education and VET.

5. INTRODUCING CHARACTERS / AVATARS

Characters or its representatives allow the audience / reader to identify with the story. The most compact guidelines for the introduction of characters can be found in film-script guidelines. Crucial in establishing characters are the features of what we call ‘a personality’. Let the listener immediately know who (s)he is via exposé of (trans)actions and contrast with the other players on stage. Make clear that (s)he is going to play a decisive role in the coming adventure. Typically, the listener should be able to identify with the main character, but at some essential point there needs to be ambiguity: ‘strange’ behaviour that cannot be explained or could not be recognized before. Overwhelm the listener very soon with typical bloopers (‘big mistakes’) by the main character. Keep your story compact so that the main line can easily be remembered. Insert looking back and forth as mental perspective; The listener is supposed to ‘create’ his/her own interpretation. In case of more abstract concepts in the knowledge domain, elaborations are needed; encourage the listener to interweave prior and final understanding and keep this discrepancy until the very end of the story. The elaboration of Story-Mapping, Hero’s Journey and the available multimedia tools for web-authoring can be found in the next link to David Mamet’s message triggers your mind on storytelling:

6. SIMULATIONS: DEFINITION OF THE CONTEXT, TEAM WORKS, SKILLS, PATHWAYS, E-TOOLS, MANAGEMENT

Both gamification and narrative discourse for learning can be seen in the many simulation programs that have been integrated in various levels from early regular unto the highest levels in corporate and civil training in everyday life already. Since computers became multimedia (Multi Modal), its potential contribution to let people explore almost any context, inclusively 3D spatial environments with stereopsis for surgical training, kinematic and proprioceptive sensations for vehicle control and haptic experience for training manipulation feedback; See Figure 2. The instructional context and the apprentice's prior knowledge and skills is decisive for what is actually learnt from a simulation model. The underlying photo of an expert surgeon who calibrates a haptic device before the students start working with it; (Kommers et. al. 2004). A typical phenomenon is that after a few hours of practicing, the novice will perform better than the expert. This is the moment that the students need to go to the more realistic context so that many more parameters like the total constitution of the patient, the smell, heart functioning etc. should be considered. As many competences imply social interaction and teamwork, also a large proportion of didactic simulations demand collaborative tasks; See Figures 3a, 3b and 3c. In the context of Utrecht University, a numberof collaborative group tasks have been developed for the sake of observation and later analysis. In terms of didactic context, it is important to discern the training of the individual pure job performance and the goals in terms of socio-cognitive development.

The Teams-Games-Tournament format (Ke, F., & Grabowski, B., 2007) originally defined by Bob Slavin (1977), prescribes an overall sequence of cooperative- and competitive group work. Skills progress through simulations has been described by Luursema et al. (2008). Its conclusion is that stereopsis only makes a positive difference when the novice has a limited capacity in spatial imagination.

Monitoring pathways of skills: One critical factor in the success of learning with simulations is the overview of students' partial successes/failures in the targeted skill domain. The underlying diagrams allow trainers to quickly analyse novices' learning performances. It is an example on how e-tools allow the human factor to survive and even excel, compared to the f2f classroom situation.

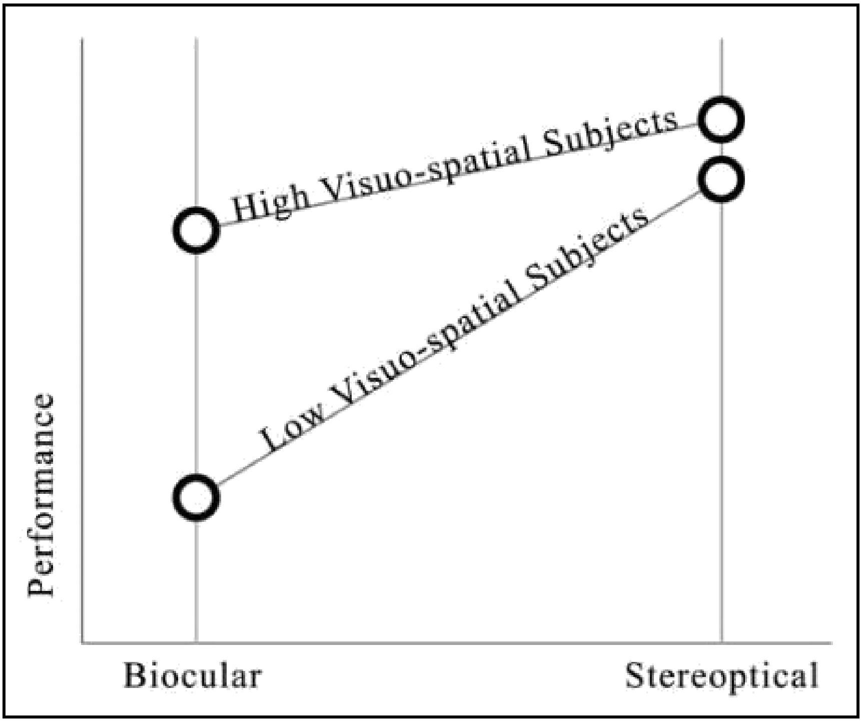

Figure 2: Luursema's finding that the added value of the heavier 3D stereoptic goggles emerges more in case of a weaker visual imagination
Source: Kommers, Luursema, Rodel, Geelkerken, Kunst, 2004

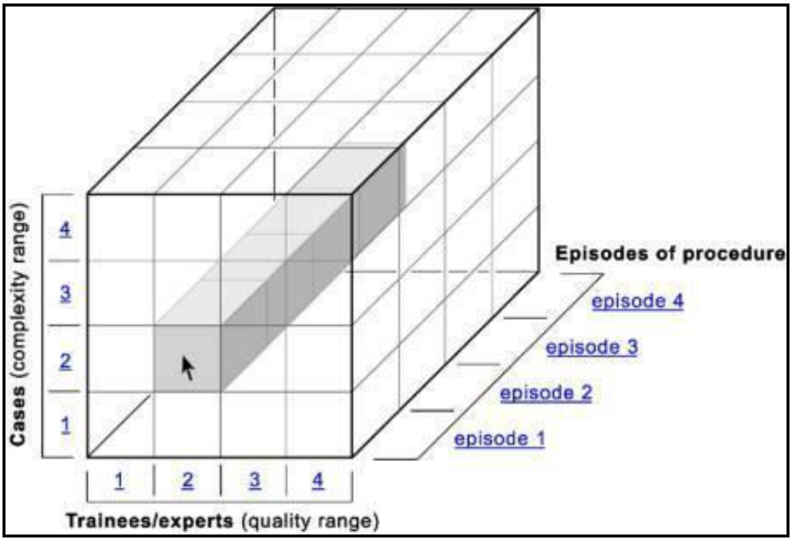

Figure 3A: Selecting a particular intervention episode across all trainees for one particular patient

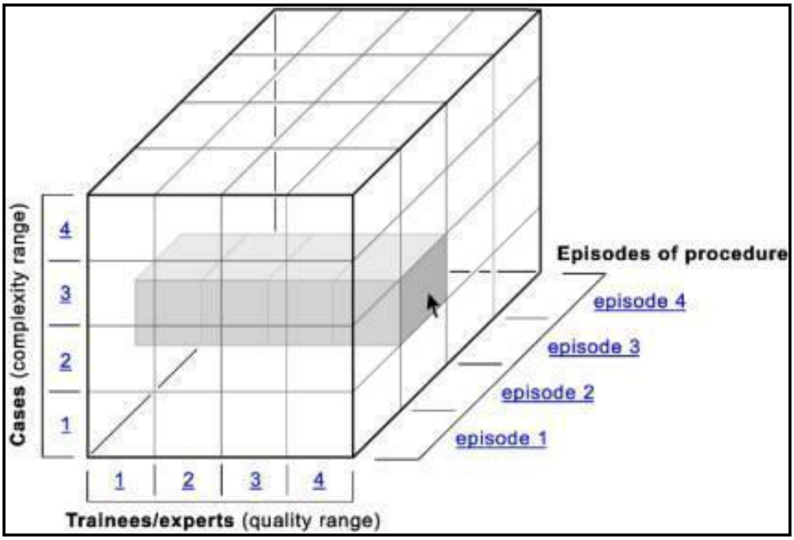

Figure 3B: Selecting a Trainee / Patient intervention history

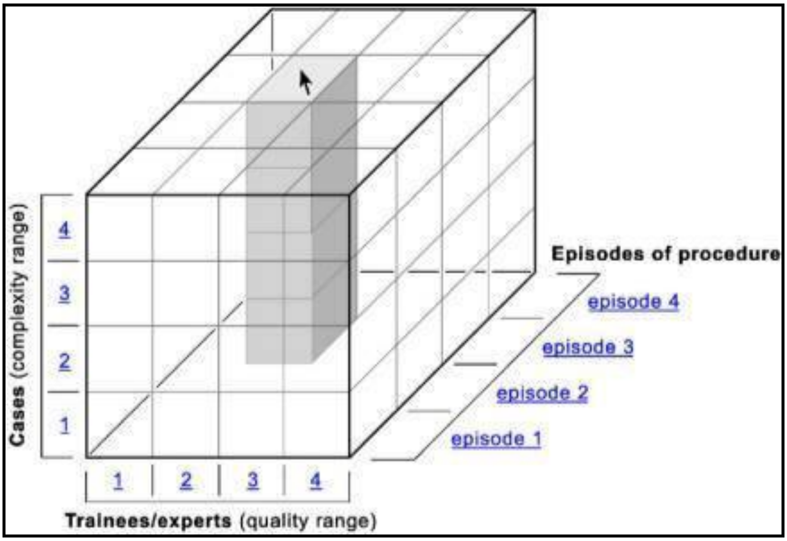

Figure 3C: Selecting a particular intervention episode across all patients for one particular trainee

Source: Kommers, Luursema, Rodel, Geelkerken, Kunst, 2004

The study by Kommers et al. (2003) revealed that though virtual reality is one of the prime candidates in vitalizing learning by its realism and direct appeal to the students' natural affordance to act upon urgencies rather than to "know" what experts are saying; VR in itself is not enough to make the learning more effective. Obviously, the realism in VR cannot exceed the real situation it self. As the experiences with Link Trainers for airplane pilots has shown, we know that the simulation can be more effective, once it elicits the novice to go into critically complex situations; exactly those situations that we never hope to meet in reality. The added value is not just that the learner's reflexes are trained to survive in the panic of preciously decisive seconds. The value is also that learners can best understand the foundations of complex mechanisms when they are forced to work on the edge of what is a success versus a failure. Training through real-patient interventions are not allowed to approach this area. That is why the VR-based medical intervention is an even better preparation to the first clinical steps compared to witnessing dozens of impeccable operations performed by the master.

Young delinquents in prison have been exposed to in the tradition of Seymour Papert's 'Mind Storms' project at Media Lab MIT. "Climbing steep slopes" was one of the typical exercises. Finally leading to the understandable challenge to "even climb back hanging walls" as a common dream in prisons.

6.1 Contexts for simulations

Simulations have been developed in industrial projects in order to prepare better for the unforeseen complexity during calamities. Its main effect was that engineers and decision makers became better prepared compared to those who just concentrated on formal models with a high degree of precision. As simulations became easier to emulate more complex realities, education has gathered more than only interest and got more and more convinced that a reduced reality had advantages for gaining understanding compared to the situation with full reality and scale. Simulation has even become a metaphor for education at large: If the real setting cannot absorb novices' presence and contributions, it is needed to build a reduced version of a particular enterprise. Not only to increase safety and flexibility for the time of learning, also for breaking-out when no urgent maintenance or trouble shooting was needed. For example, Hewlett-Packard's inkjet cartridge filling factory in Dublin had a mini factory where employees could exercise in fault-finding so that they reached a shorter downtime in case of failure. In other words, simulations have a wide potential scale of functions. Its use for learning purposes can be focused on tackling renowned problems like flight pilots who need to practice emergency landings that they would never voluntarily undertake in reality. But also, simulations allow novices to explore and experiment configurations in order to develop a better. What-If thinking for the cases that fresh reasoning is needed in a future break-down.

CONCLUSIONS

Entrepreneurship-oriented learning like gamification, storytelling, simulations etc. can only be adopted and effectively integrated if an overall pedagogical framework has been articulated. Problem-Based Learning seems the best candidate as it places the learner at the very core of the life-long learning process. (and subsequently fading) is seen as a safe way to make learners less dependent on the teacher and institutional guidance. The same is true for the initial and further (in-service) training of Higher Education teachers. The choice of “narration” is a clever choice to let existing Higher Education trainers build upon their prior traditions and reflexes; (Kommers & Simmerling, 2015). At the same time, they need an appropriate didactic framework that allows all the upcoming ICT tools to be integrated by the learners themselves. At the moment it is gamification and simulations. In the near future it will be a wealth of MOOCs, Big Data applications, Learning Analytics, Artificial Intelligence, etc. The chosen didactic framework is Problem-Based Learning with an ever-stronger focus on the existential factors of the learner with his/her unique talents.

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DEMOCRATIZING POTENTIAL OF DISTANCE EDUCATION

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Abstract: *The article presents results of research for the purpose of which a hundred of exam sheets were analysed and answers to the questions related to the material covered during lectures, tutorials and via distant education (DE) modules were compared. It was found that the level of students' understanding the lecture material varied. The research showed that sometimes students who got the lowest grades were more familiar with issues presented via DE modules than with those discussed during lectures. The students who were experienced in using the MOODLE platform obtained 91% for questions referring to material covered in DE mode. Group 1, which did not have any DE classes before, achieved lower grades in-the exam.*

Keywords*:* lecture, tutorials, blended learning, exam, effectiveness

INTRODUCTION

Highly motivated users benefit the most from DE (Blieck, 2018: 91). These include people with physical and cognitive disabilities (Fryia, 2009, Cinquin et al., 2019), stay home parents, students living at a significant distance from a school or university (Rzeźnik, 2006: 131). The average DE users do not often study systematically. Hence, there is a high dropout rate in e-learning (Blieck et al., 2019).

There is still controversy over the reasonableness of replacing some of the traditional, presence-based classes (lectures and tutorials) with DE modules. Opponents of DE link direct contact with the lecturer exclusively with the opportunity for asking questions, for multi-channel communication and thus with more efficient perception of lecture content, with better understanding of problems being discussed and hence with greater effectiveness of teaching.

1. AIM, HYPOTHESIS AND METHODS

The aim of this study was to examine the extent to which students acquire knowledge during traditional, presence-based lectures and tutorials and to which by DE mode. The research method included:

1. analysing three test exam sheets for points scored for knowledge of material discussed during lectures, tutorials and via DE,

2. analysing and comparing official documents sourced from the Virtual University service containing average annual grades of students participating in the study.

In addition, analysis included documents prepared exclusively for this study - surveys carried out among students after Exam 1 aimed at finding their attitude to learning in virtual environment.

The research question of the study was: Does generation Z learn better when taught on a direct contact basis or in the digital environment?

A hypothesis was formulated: *students benefit the most from blended learning*. In order to test its validity, a series of case studies (Stake, 1995) was carried out and the results of exams in two subjects conducted in five groups of students were analysed. The author analysed correct answers to questions related to the content presented during the lectures, discussed during tutorials and published on the platform in distance education mode (as blended learning approach).

The author chose to carry out longitudinal, mixed, comparative, nonexperimental research (Burke 2014). The quantitative research included statistical analysis which allowed comparison of sums and percentages of grades and scores obtained by different groups of students (Pasikowski, 2012: 121). Additionally, coefficients were calculated, including Spearman R_S rank correlation coefficient. Quantitative research which was insufficient for the research problem being studied was supplemented with a qualitative analysis of the students' behaviour, its dynamics and change patterns over time.

The phronetic approach to research (Tracy, 2007, 2013: 4) is based on relating systematically gathered data and its interpretation to real world in order to introduce positive changes, which, in this case, included improving the overall education system and the way students are examined. *Phronēsis*, understood by Aristotle as "prudence" and "practical wisdom" (Aristotle, 2004: 193) implies the accumulation of contextual, action oriented and values-dependent knowledge (Cairns & Śliwa, 2008).

2. RESEARCH MATERIAL

Data available in the form of examination sheets for the modules *Fundamentals of Social Communication* and *Theory of Media and Communication* filled by second year students of the undergraduate courses: *Culture and Media Studies* and *Polish Philology* (specialty: *Social and Media Communication*), as well as first year master's degree students of Culture and Media Studies in the module of Theory of Media and Communication. Lectures, tutorials and DE instruction were delivered in the academic years 2017/2018 and 2018/2019 and the exam papers came from three examination sessions held during those two years.

Students in *Cultural and Media Studies* and in *Polish Philology* jointly participated in lectures and classes, while they attended tutorials separately in the Institute of Polish Philology (Table 1, Table 2, Table 3).

Table 1.

Exam 1. – in Fundamentals of Social Communication

	Polish Philology, Social and Media Communication 2nd year undergraduate students (Group 1)	**Culture and Media Studies, 2nd year undergraduate students (Group 2)**
Number of students	7	52
Number of lecture hours	14	18
Number of on campus tutorials	30	16
Number of the DE hours	12	8
Number of questions on lecture content	12	12
Number of questions on tutorials content	6	6
Number of questions on DE content	7	7

Source: Own work

Table 2.

Exam 2. – in Theory of Media and Communicatin

	Polish Philology, Social and Media Communication 2nd year undergraduate students, (Group 3)	**Culture and Media Studies 2nd year undergraduate students (Group 4)**
Number of students	9	11
Number of lecture hours	12	10
Number of on campus tutorials	24	20
Number of DE hours	6	6
Number of questions on lecture content	10	10
Number of questions on tutorials content	20	20
Number of questions on DE content		

Source: Own work

Table 3.

Exam 3. – in Theory of media and communication

	Culture and Media Studies, 1st year master's degree students (Group 5)
Number of students	21
Number of lecture hours	10
Number of on campus tutorials	10
Number of DE hours	6
Number of questions on lecture content	12
Number of questions on tutorials content	6
Number of questions on DE content	2

Source: Own work

3. LIMITATIONS

The study was conducted on a small sample, so it is highly probable that external factors had an impact on the results e.g. students' personalities, lecturers' personalities, social opinions about DE, technical problems, family and/or health status etc.

4. RESULTS

4.1. Effectiveness of each type of classes

The percentages of points scored by students for questions related to the material presented during lectures, tutorials and DE were compared. It was found that the DE used by competent (master's degree) students was the most effective type of education (see Group 5). Distant education is effectively used by talented (see Thomson, 2010) and inept students alike. But those who are less motivated and less technically advanced learn the least effective from a distance.

Table 4.

Percentage of correct answers to questions related to material discussed during lectures, tutorials and via DE

<table>
<tr><th></th><th></th><th>Lectures</th><th>Tutorials</th><th>DE</th></tr>
<tr><td rowspan="2">Exam I</td><td>Group 1</td><td>70%</td><td>69%</td><td>41%</td></tr>
<tr><td>Group 2</td><td>68%</td><td>79%</td><td>75%</td></tr>
<tr><td rowspan="2">Exam II</td><td>Group 3</td><td>74%</td><td colspan="2">69%</td></tr>
<tr><td>Group 4</td><td>78%</td><td colspan="2">76%</td></tr>
<tr><td>Exam III</td><td>Group 5</td><td>79%</td><td>57%</td><td>91%</td></tr>
</table>

Source: Own work

4.1.1. Knowledge of lecture content

Table 4 shows that on average students score about 70% for their knowledge of lecture material and this is a stable trend resulting from the traditional nature of this form of university education. However, the effectiveness of lectures varied between 68% and 79% in the studied groups. The experienced master's degree students who attended the lectures in small groups benefited the most (Group 5: 79%, Group 4: 78%). On the other hand, undergraduate students who attended the lectures in large groups learned the least (Group 2: 68%, Group 1: 70%).

It can be said that the lectures can contribute to increased differences between students. Reducing education to lectures only or excessive use of them in case of the digitized generation Z (also known as Post-Millenials, multitasking generation, @ generation) leads to an inequitable distribution of knowledge among young people for whom digital environment is the main area of constant acquisition of knowledge about the ever-changing world.

This observation is important especially in case of post-communist and post-colonial countries in which there are still present social inequalities – the remnants of the previous systems. Acquiring knowledge – as many other organized human activities – is influenced by the social environment. Social relations of power affect students, academic teachers and researchers (Kuhn, 1962; Lincoln & Guba, 2000; Heilbron et al. 2018). Transfer of knowledge by means of outdated and undemocratic presence-based, traditional lectures only deepens existing social inequalities in its distribution, and thus increases social divisions.

4.1.2. Knowledge of the tutorial material

Despite the long academic tradition of the tutorials, in case of many students they were ineffective. Their effectiveness ranged from 57% to 79%, so it depended on various factors.

The second-year undergraduate students of Culture and Media Studies who were split into two groups and instructed by an experienced tutor benefited the most from the tutorials. During the exam, they provided better answers to questions related to the issues discussed during tutorials than to questions related to the material discussed during traditional lectures. The difference here was as high as 11%.

On the other hand, students from the master's degree course, Group 5, benefited the least from the tutorials. Although they were experienced and able to organize their own learning, they provided correct answers only to 57% of questions related to the topics discussed during tutorials. It negatively impacted the results of their exam, because they remembered the material presented in the DE mode in 91%, and material presented during the lectures in 79%. Such a low educational effectiveness of the tutorials may have resulted from the fact that they were not connected with DE content, as the students had been used to having tutorials content available on-line. Moreover, tutorials in this group were run by an academic who did not utilize the DE mode for teaching.

Therefore, the effectiveness of the tutorials depended on external factors which influenced the students' overall results of the exam, even in case of experienced master's degree students.

4.1.3. Knowledge of the content discussed via DE

The DE tutorials did not have the desired effect in cases of students who were not familiar with this form of education. A small group of second year female students of *Polish Philology* were not familiar with DE during the first year of their study. This group even questioned classes with the use of digital technologies because they required personal involvement from the students, meeting technical expectations, gave opportunity for tracking their online activity, required lots of reading and precisely following instructions as well as the skills for using the appropriate software. Meanwhile, when students from this group started their first degree, they expected that traditional education based on working with textbooks will be continued in the second year of their studies in *Polish Philology*. They distanced themselves from digital technologies and did not wish to invest in laptops being convinced that they would not need them for their studies.

Additionally, also the academics looked unfavorably at DE because they associated it with increased workload~~s~~ inevitable in preparation and delivery of the DE and blended learning classes, related to this time pressures, need for technical advancements and the need to update their qualifications but also unclear intellectual property rights to the teaching materials created by them, lack of financial recognition for time spent preparing for the DE classes and involvement in the DE not being recognized in appraisals of the academics and the university.

The low effectiveness of the DE (40%) in small Group 1 composed of first degree students of *Polish Philology* who upheld a conservative outlook at teaching methods contrasted with the high efficiency (91%) of the DE instruction in Group 5 composed of second degree students of Culture and Media Studies who had previously participated in several DE-based courses, were able to organize their learning, meet time lines and efficiently use electronic resources for expanding and deepening their knowledge. In this case, the DE classes were successful because they were run in a favorable environment which included competent students, an experienced tutor, supportive educational institution, appropriate technological facilities, well-organized education system, etc.

All the above factors caused that over time the students were able to use digital materials and the DE tutorials more and more efficiently. The percentage of the correct answers to questions related to content of the DE is shown in the last column of *Table 4*.

4.2. Efficiency of the DE classes

When the results of Exam 1 were analyzed, due to the lack of the normality of the distribution of both the number of points obtained by students for knowledge of issues discussed during lectures and the exam score, non-parametric tests were used. The Spearman R_S correlation coefficient was used to study the relationship between these two features. A statistically significant ($p = 0.000019$) relation between the number of points obtained for knowledge of content of the DE classes and the exam score ($R_S = 0.53$) for all students ($n = 59$) was obtained. It is a strong monotone correlation, which means that the higher the number of points obtained for questions related to the DE classes the higher final exam grade. The detailed distribution of grades, depending on the number of points obtained by students for their knowledge of the lectures. The trend is shown in Figure 1.

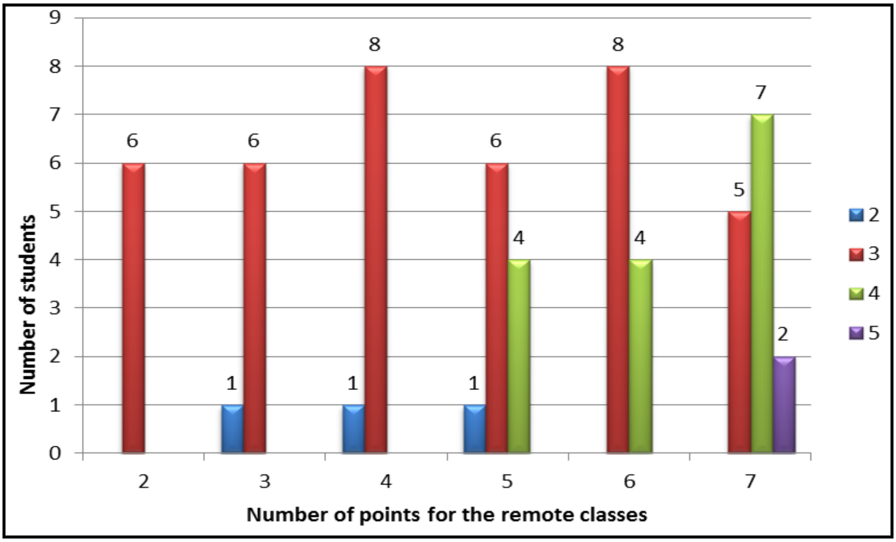

Figure 1. Exam 1 – grades vs active participation in DE classes
Source: Own work

Figure 1 shows that six students received only two points for knowledge of the content delivered via the DE classes. All those students, however, passed the exam (obtaining Credits) because as their progressed in their learning they were getting feedback on their poor results. Therefore, they were aware early enough that the knowledge they got was not sufficient, so they kept on improving it during tutorials and lectures and by using published digital educational resources.

On the other hand, three students who received respectively 3, 4 and 5 points for their knowledge of the issues discussed in the DE classes (43%, 57% and 71%) did not pass the exam. It means that two students had little knowledge of the content of the DE classes. On the other hand, two students who received high distinction for Exam 1 also got the maximum number of points for their familiarity with the content of the DE classes. Students working the most poorly were, therefore, able to complete the majority of questions, and the highest grades went hand in hand with the best knowledge of the DE classes' content. This trend is illustrated in *Figure 3*.

In *Figure 2*, one can also see that the DE classes were easily apprehensible to all students: the poorest performing ones managed to complete assignments, and the average number of points scored by a student was 4.98 out of 7 possible i.e. 71%. It is also evident that the students from the group which worked most intensively with the DE part of the unit were awarded the highest grades for the exam (high distinctions).

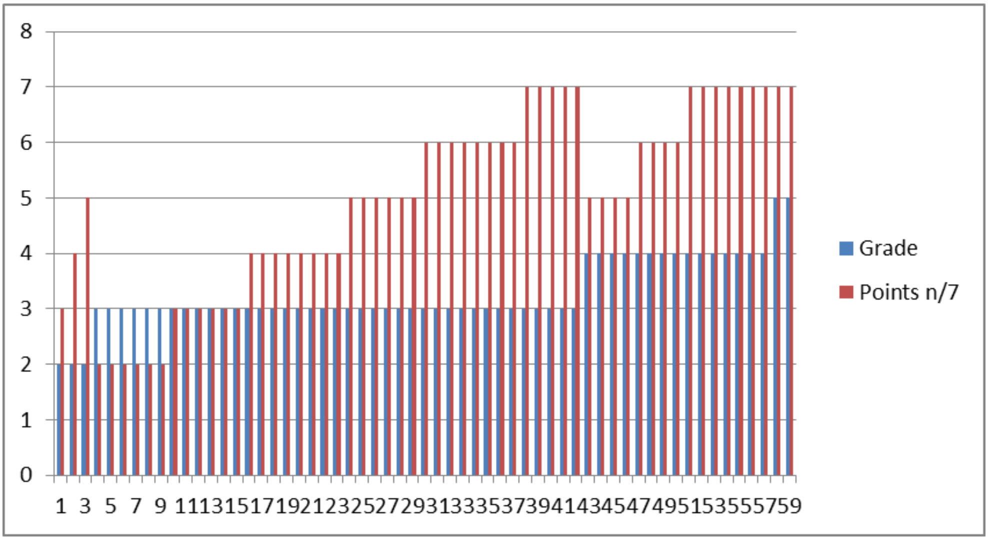

Figure 2. Exam 1 – grades for students' active participation in DE
Source: own work

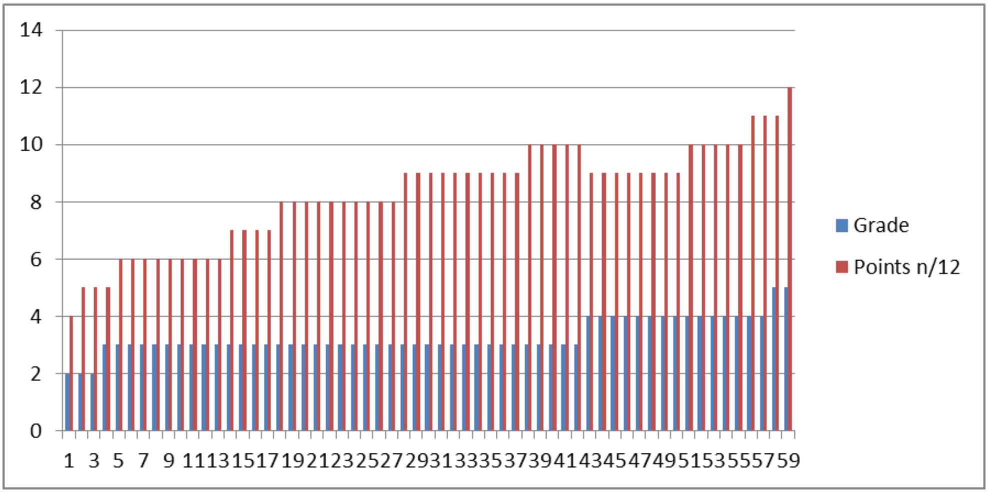

Figure 3. Exam 1 – grades for knowledge of the lectures' content
Source: Own work

On the other hand, the lectures were not as easily comprehended by the students as the DE classes. Lectures proved to be differentiating the students. A statistically significant ($p < 0.000001$) correlation between the number of points obtained for the lecture and the exam grade ($R_S = 0.67$) for every student ($n = 59$) was obtained. *Figure 3* shows, however, that the most poorly performing students who did not pass the exam also failed to benefit from the lectures scoring only 33% and 38% i.e. 10%-33% less than for their knowledge of the DE classes' content. Only one student managed to get 100% for their knowledge of the lectures' content, while in the case of the DE classes as many as 14 students managed to get that score. Nevertheless, *Figure 3* shows that it was not necessary to obtain the maximum number of points for the knowledge of the lectures' content in order to be awarded the top grade for the exam. The lectures, then, turned out to be less comprehensible and less useful for obtaining a high distinction for the exam than the DE classes; even though the students could receive maximum of 12 points for the lectures and only 7 for the DE classes.

Therefore, it can be concluded that the level of understanding and degree of retaining the lectures by the students were more diverse than the level of understanding and degree of retaining the easy to comprehend and to follow content delivered via the DE mode.

4.3. Correlation between the DE classes and exam results

There were various correlations discovered between the results for the knowledge of DE content and the results of the exam:

1. Three students who received feedback while attending the DE classes informing them that they scored low, improved their poor result by working more intensively; also during tutorials and lectures.

2. Three students who did little or did not do any work in the DE classes (a student who did not sign in to DE classes, attended lectures and exercises, but did not take the exam) failed the exam.

3. Only those students who used the DE classes most intensively obtained distinctions and high distinctions for the exam. The student who passed the exam the best was among the most active students in the DE part of the unit, because she made the use of the available additional resources.

Therefore, it can be said that DE had a democratizing character: it helps poorly performing students to pass the exam, and it assist the average and capable students in broadening and deepening their knowledge. Students who did not spend enough time on the DE content did not pass the exam.

4.4. The distribution of knowledge of students who were the most and the least successful in the exam

Nine students who obtained the best results in Exam 1 statistically utilized the classes to the greatest extent, in 5 cases obtaining 100% for tutorials' content. In case of the lectures, only the student, who passed the exam with the highest score, benefited from them to such an extent. Three good students from this group gained more from the DE mode than from the lectures. This means that for the best students the lecture was not the most suitable form of knowledge transfer. This is illustrated in *Figure 4*.

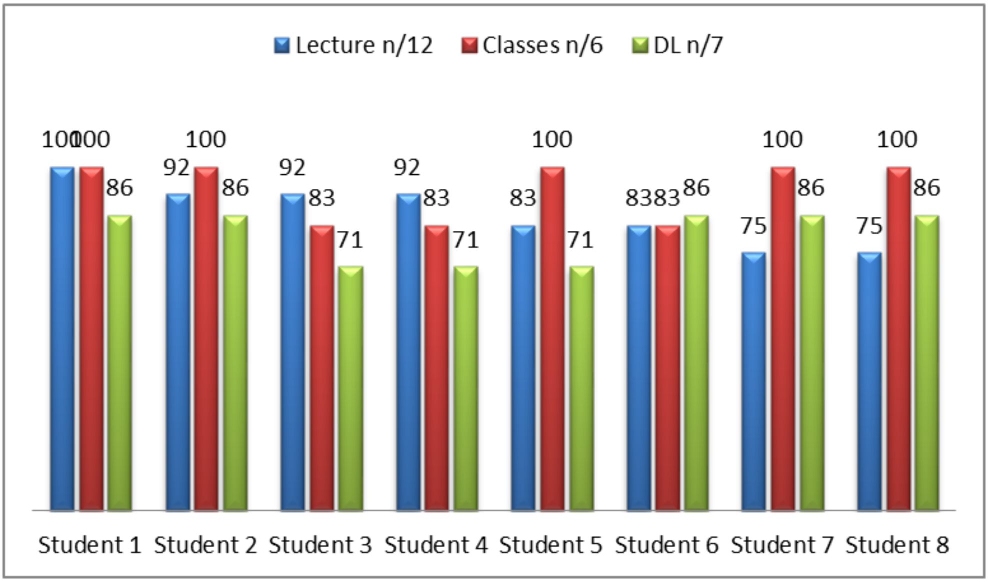

Figure 4. Exam 1 – distribution of the best grades
Source: Own work

Students who got the lowest grades also learnt the most during classes (students 3 and 8 scored 100% for questions on tutorials' content). Only for two students, lectures turned out to be the most effective form of knowledge transfer. Also, two students (6,7) gained more from the DE than from lectures.

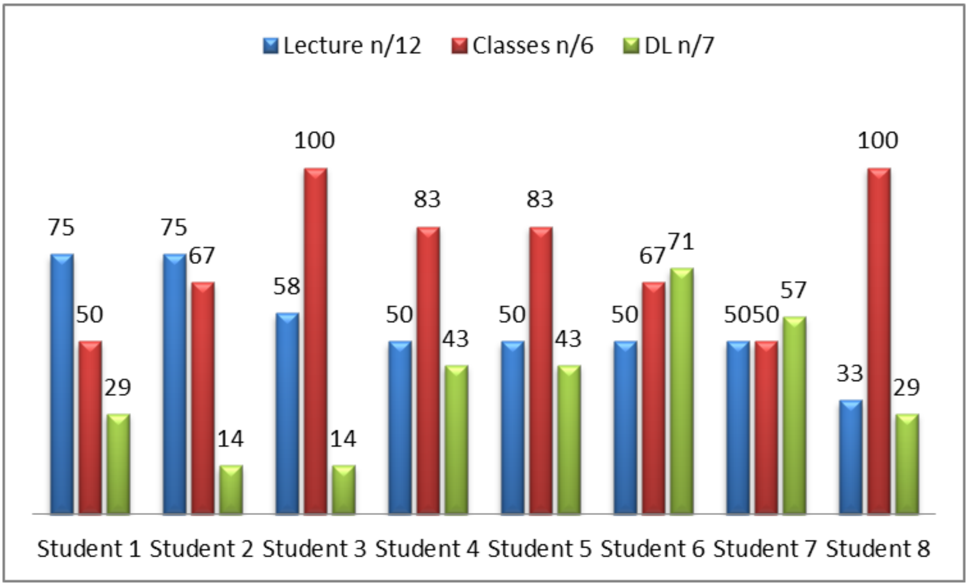

Figure 5. Exam 1 – distribution of the lowest grades
Source: Own work

Figure 4 and *Figure 5* show that the lectures were not the most effective form of knowledge transfer neither in case of talented nor below-average students. All students required tutorials, while some preferred DE.

4.5. Grades of students freshly commencing the DE classes - Group 1

Group 1 students who have not used the DE classes before (n = 7) obtained an average of 2.86/7 points (41%) for questions relating to content delivered via the DE mode. The student who answered 4/7 questions regarding the content of the DE classes but was not familiar with the content of lectures and tutorials failed the exam.

Other students from Group 1 got satisfactory marks for the exam and those grades were related to correct answers to 2-4 questions regarding content of the DE classes. Group 1 got very low grades for Exam 1 – average 2.85, while in Group 2 the average grade was 3.26.

On average, both groups obtained a higher final grade-average than for the Exam 1: Group 1 achieved a final grade-average of 3.83 (0.98 higher than for the exam), and Group 2 achieved 3.92 (0.66 higher than for the exam). Group 1 students were unpleasantly surprised with their low grades their obtained for Exam 1, especially when they compared them with Group 2's exam results. They suddenly realized the ineffectiveness of their learning method.

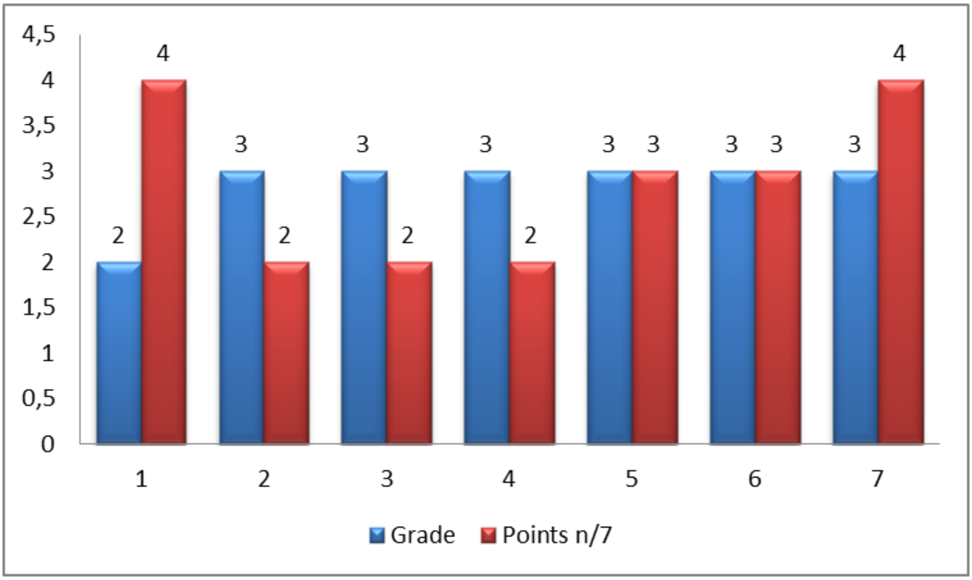

Figure 6. Group 1 – grades vs students' active participation in DE classes
Source: Own work

Five months later Group 1 took Exam 2 as Group 4 comprised of nine students. The DE classes were combined with tutorials and delivered as blended learning – the issues discussed in the classroom were explored in a digital environment.

This time the students achieved better results because they were already better acquainted with the Internet and *computer applications* (Picciano & Seaman, 2007, Kintu et al., 2017). On average, they obtained 15.33/20 points (76%). Students who provided the best answers to questions related to blended learning content also passed the exam the best. The students who were not very much familiar with the virtual learning environment received the lowest grades for Exam 2. This is illustrated by *Figure 7*.

The correlation between the use of blended learning and the result of the exam may be related to the fact that more committed students were willing to do various exercises and to gain additional knowledge. On the other hand, the less involved students did not take the effort and did not want to participate in the DE classes, which involved the need to review additional education materials, doing exercises under time pressure and assessing their knowledge.

On the other hand, the correlation of the number of points obtained for the responses related to the lectures' content and the exam grade in the case of Group 4 was less pronounced. Students who answered 6-9 questions related to the lectures (span of 3/10 points or 33%) received good grades. In the case of blended learning it was 16-18 points (span 2/20 points or 10%). Therefore, it can be said that the answers to questions related to material discussed during lectures were not as strongly correlated with exam grades as answers to questions associated with issues discussed during blended learning classes. This trend is illustrated by *Figure 8*.

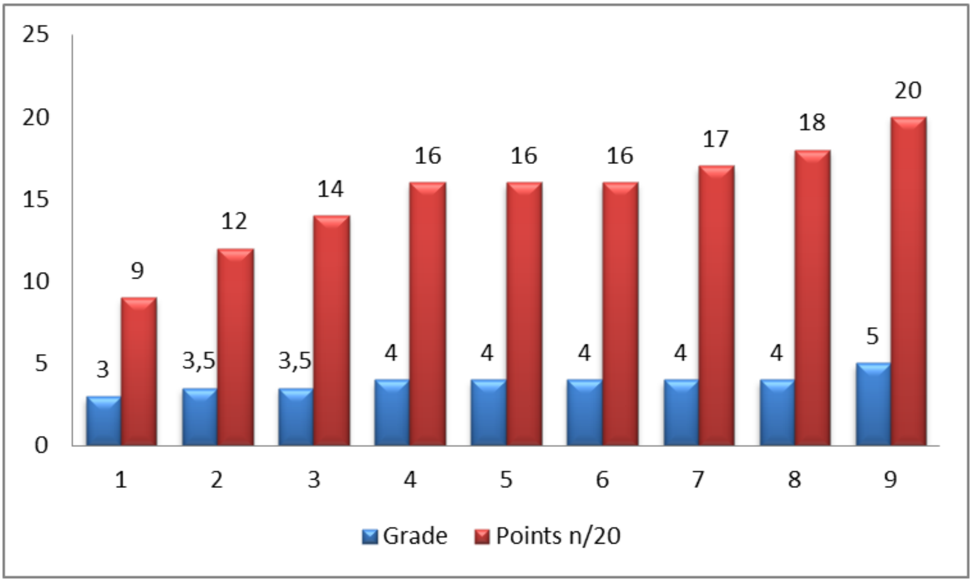

Figure 7. Group 4 – grades for knowledge of the content delivered in blended learning mode
Source: Own work

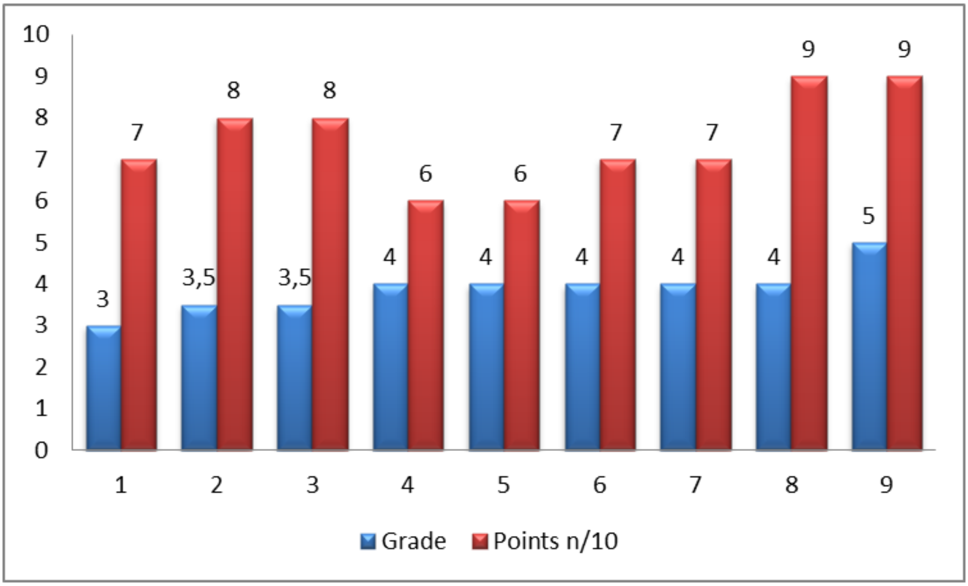

Figure 8. Group 4 – grades vs answers to questions related to lectures' content
Source: Own work

5. STUDENTS' OPINIONS

After Exam 2, an anonymous survey was conducted to obtain information on research participants attitudes toward e-learning. 32 questionnaires were returned. 19 students perceived the advantages of DE: *you can acquire knowledge calmly, at your own pace* [10], [DE teaches you:] *how to quickly make use of information* [4], *how to work independently and be disciplined* [14], *how to manage time effectively* [25]; *one can send posts on the forum, see the presentations made by others and learn from their mistakes* [7]; *increase* [the quantity] *because they are interesting* [1].

On the other hand, 14 students indicated the disadvantages of the learning mode via DE considering self-evaluation exercises [10, 16], non-compulsory chat [11, 15], and even compulsory tests [12, 13, 17, 18, 23, 24, 25] unnecessary.

All students have succesfully passed tests which were part of the DE course. However, 21 respondents said that the time limits for completing the tests were too stringent, for example: *we have spent a certain amount of time and instead of focusing on tasks we think only about elapsing time* [26], *there is not enough time allowed for the completion of the quizes, it could be better if there were no time* [limits]. *Then, quizzes would be easier and less stressful* [3], *time limits stress students and they do not focus on deepening their knowledge* [14].

It can be said, then, that the second year students of the first degree courses have some difficulties mainly with their time management. This is in line with the observation that teaching in the digital environment fails due to the students' difficulties with time management (Rovai, 2003; Selim, 2007; Clarke 1999).

6. CONCLUSIONS AND RECOMMENDATIONS

The research hypothesis was confirmed: *students gain the most knowledge from blended learning*. This means that DE has a democratizing potential. The results of the study allowed for the formulation of the following statement: *the Z generation students gain more from the learning via DE than from lectures*. Because the DE forms include proven: additional materials. Exercises and self-evaluations and it is also a more reliable source of information than improvised stationary tutorials.

Further comparative research on the effectiveness of lectures, tutorials and e-learning is needed. Larger samples, various environmental, age-related, cultural etc contexts should be studied. On the basis of the presented research results one can attempt to put forward a theory on the democratizing potential of blended learning and DE. Such a theory would be an additional impulse for the development of this form of teaching, and this development is inevitable (Zalewska, 2015: 112). Such theory would also most likely contribute to the greater interest of the conservative academics in DE and would greatly assist in obtaining wider support of decision makers for developing such university platforms.

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E-LEARNING IN A SUSTAINABLE SOCIETY

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Abstract: *The paper focuses on e-learning to support IT (information technology) skills for a sustainable society. Perhaps all entrepreneurs are interested in innovation, artificial intelligence and industry 4.0. IT delivers solutions in the form of simulation, alerting, autonomous robots, and machine learning based on artificial intelligence data. For education and e-learning, it is the responsibility to refine the skills of students to work with intelligence and automated processes. Advanced skills are needed to work with an intelligent personal assistant, intelligent knowledge navigator, smart calendar, views of social media conversation, or personalized marketing. Practical examples are based on experiences from courses devoted to operating systems and CRM systems.*

Keywords: automated processes, e-learning, information technology, intelligences, sustainable society.

INTRODUCTION

The theme of sustainable society is increasingly important for the future of life on the Earth. People use information technology to share experience and knowledge. Day-to-day activities are changing at a rapid rate through innovations and hard pressure of market. It is a competitive society, but life is not just about a competitive environment. Life is precious and it is important to develop life in all forms with respect. From long-term life on the Earth, this is the age of a sustainable society (Sachs 2015). A sustainable society promotes real development needs from presence to the future that all generations may live in. Rules based on a competitive society often bring conflicts. This reality has solutions linked to a sustainable society and sustainable development.

This development affects the social, environmental and economic conditions of life (Miller, 2014). Information technology is used in all activities and it is natural that information technology also has an important place in sustainable development.

Sustainability is necessary for all aspects of life. Perhaps everyone will devote the first thought to energy, water and food. These aspects are associated with changes in energy technology, minimizing water consumption and increasing food production with optimal quality. And it is not all. The changes are also designed for processes in manufactures and are increasingly one of the most important technologies such as information technology (Caets 1995). In the last century, information technology has provided support through information systems in various forms and contexts (Williamson & Johanson, 2017) such as Transaction Processing System (TPS), Management Information System (MIS), Decision Support System (DSS), and Online Analytical Processing (OLAP). There are many proven approaches to developing these information systems to support operating and database systems with links to various intelligences and data mining.

Information technology and knowledge (Barbosa 2018) are irreplaceable for a sustainable society with different forms of intelligences (Lamm 2018) such as product, customer, competitive, business, and artificial. For the current view of e-learning in a sustainable society, this paper is divided into several chapters. The first two chapters focus on the real view of a sustainable society and the new roles of intelligences for industry 4.0. The third chapter is about the importance of e-learning and education 4.0. The actual contribution of this work is evident in the fourth chapter, which describes the integration of automated processes and intelligences into courses focused on operating systems and CRM. The aim is to extend knowledge of students about work with selected operating and CRM systems based on automation and intelligence.

1. SUSTAINABLE SOCIETY

The importance of sustainable development is evident in the specification of a sustainable society. A sustainable society is a measure of consumption with respect to the environment and the balance of resources. It is about equality of citizens, freedom and a healthy standard of living (United Nations 2018; Bonnedahl & Heikkurinen 2019). In Europe, it is the urgency of progress based on the implementation of sustainable development in the activities undertaken to achieve a more sustainable future with regard to solidarity and human rights, social justice, equality, democracy and participation, entrepreneurship and environmental responsibility (Sustainable democracy in Europe 2019).

The importance of a sustainable society is becoming increasingly important in the context of efforts to prevent financial crises and people's passivity to life. There are also predictions about a new financial crisis from some experts, and again about doubt from the devastating effects on economies (Sustainable

Equality 2018). Reaching sustainable society goals goes through innovation in business that combines information technology, infrastructure and human sources (Peris-Ortiz et al. 2018). Focus is on drones, robots, and artificial intelligence in many implementations based on special training program and performance assessment methods. These include transparency, decision-making processes, product information for consumers, independent reports, and good information orientation that provides access to verified data against online disinformation and fake news.

Basic information skills, cooperation skills and more experience are important. Education and information on sustainable society and best practices have to be at the forefront of e-learning. At all times developing knowledge and information enables prosperity and better quality of life. It is about ability of change and innovation based on new technologies, which new technologies will have a positive impact on global society (Johannessen 2016). Again, this is artificial intelligence, robots, and other scientific and technological changes that are visible in machine learning algorithms to improve service quality.

Current forecasts say that new technologies will have a negative impact on jobs, as many routine jobs will be lost as we know today. However, new jobs will be needed, with links to new technologies. It will be about high specialization and optimal skills and knowledge. The pace of technological change is unexpected and it will be a big challenge for education and e-learning to have optimal methods (Collins & Halverson 2018). Towards a sustainable society requires optimal e-learning and dialogue on sustainability to have good knowledge and skills. There is room for workshops, webinars, forums and other projects that use information technology for the new roles of intelligences and industry 4.0.

2. NEW ROLES OF INTELLIGENCES AND INDUSTRY 4.0

The new roles of intelligences are fundamental in industry 4.0. Industry 4.0 introduces the idea of smart factories, where machines have added web connectivity to integrate them into one system for visualizing production and making decisions on their own (Embracing Industry 4.0 2019; Pabbathi 2018). Intelligences play an important role, but there are other technologies that transform industry. These include big data and analysis, autonomous robots, simulations, system integration, the Internet of things, cyber security, cloud, additive production and augmented reality.

Smart technologies are important for creating information technology and implementing it in practice. One of many examples is about customer relationship management (CRM) systems. In the new century, CRM systems must be more than a place to store data in a database (Fatouretchi 2019). There are alerts, simulations, and autonomous learning based on data with artificial intelligence. Such an approach requires the collection and comprehensive evaluation of data from many different sources and customer management systems, such as the standard for real-time decision support.

Artificial intelligences have a practical implementation in different situations. The idea is that search engines use it to improve answers to queries (speech recognition, language translations), email programs use it to filter spam, banks use it to predict exchange rates and stock markets, robots use it to localize obstacles, autonomous cars use it to drive, video games use it to improve player experience, or smartphones use it to recognize objects (Narula, 2019; Schmidhuber, 2019).

In order to gain a competitive advantage from information technology, it is important to know about needed terms and work with them to adopt a framework of intelligences and technologies for a sustainable society. It is about integrating artificial intelligences and other powered automation and prediction across the enterprise. This method is based on three steps (Lamm, 2018).

Step 1: Clarify what focuses on business and what to automate such much as possible. Information technology processes are more integrated with artificial intelligence and automated.

Step 2: Artificial intelligence is used to collect and interpret data, making it easier to figure out what does not work and why.

Step 3: Realized analysis will lead to better prediction of product chain parts. Such automatic implementation leads to an improved machine learning system.

Good implementation of artificial intelligence is strategy based. The changes are focused on smarter products and services, better business decisions, automated business processes. The artificial intelligence strategy is based on nine areas such as business strategy, strategic artificial intelligence priorities, short-term artificial intelligence adoption priorities, data strategy, technology issues, skills and capacity, implementation, and change management issues (Marr 2019).

The first step to creating artificial intelligence strategy is by reviewing the business strategy that there is an obvious relationship of artificial intelligence to business goals. Strategic artificial intelligence priorities specify the main business priorities, problems to solve, and how artificial intelligence helps achieve strategic goals. It is about developing smarter products and services, more intelligent business processes and functions, or automating production processes. The short-term artificial intelligence adoption priorities focus on the ability to optimize processes quickly and cheaply. It is about smaller projects that help make artificial intelligence a priority.

Good work of artificial intelligence is based on many data. So artificial intelligence needs data, big data. There is a place for a data strategy to show whether there is the right sort of data, enough of data, the right type and volume of data for artificial intelligence priorities. It is also a way to get the data you need and set up new data collection methods. Technological issues are interested in the technology required to achieve artificial intelligence priorities such as machine learning and deep learning. Implementation is about ideas to get artificial intelligence into reality through projects, key steps, and defined responsibility for actions. The volume of work is large and therefore information technology cannot be in interest of one department. For example, customer service and marketing teams work together to create a competitive advantage (Siggelkow & Terwiesch 2019) with artificial intelligence. Their understanding and direct customer experience contributes to intelligent system training. It is also about further e-learning and education.

3. IMPORTANCE OF E-LEARNING AND EDUCATION 4.0

E-learning is an important key to strengthening equality among people globally and locally. The whole global world economy requires knowledge and skills for international exchange and collaboration (McLagan 2017). Access to appropriate forms of education for all is a way to improve knowledge, prevent poverty and enable future generations to create a sustainable society. In this context, this theme has an impact on the role of education at all levels.

There are projects in education that use intelligences to help students and teachers gain more from their learning experience. Good experiences are with the implementation of artificial intelligence, such as: artificial intelligence automates educational activities such as grading, educational software is adapted to student needs, artificial intelligence seeks places where courses need to be improved, students have additional support from artificial intelligence teachers, artificial intelligence driven programs give students and teachers feedback, and artificial intelligence alters the way they find and communicate with information (10 Roles For Artificial Intelligence In Education 2018).

For e-learning, it is also important to introduce advanced IT practices into work with information technology. It is important that students, such as IT users, work with operating and information systems fixed with all benefits. The situation is harder because information is available, for example, on Google and many students think it is sufficient. However, the seminars show that this is a great weakness. It is not about finding information, but searching for optimal information with the following work.

For example, students who study an operating system in a bachelor's degree (the field of Managerial Informatics) have to select an operating system for practical work according to Linux/UNIX preferences. The Internet offers many life images that are used in a virtual environment such as Oracle VM VirtualBox or VMware Workstation Player, and the teacher prepares selected life images for seminars with advice on how to do it. This software is free and therefore used for learning without restrictions. Unfortunately, some students have difficulty selecting the live operating system image according to their preference. The reason is, for example, that they try to work in this life image with knowledge of another similar operating system. In many cases, it is almost identical, but there are differences. Some students also have an operating system experience like Ubuntu or Fedora, but have lost up-to-date information and their orientation rate is lower. Overall orientation is good with basic operation on Linux/UNIX operating systems, such as user environment, user account creation, and displaying of important configuration files, but monitoring and configuration changes are already a problem.

Another example is a first degree course focused on CRM systems in (the field of Managerial Informatics). It also includes advice on how to work with selected CRM systems to optimize the focus on the possibilities offered by information technology. Students have also to select a CRM system for active work according to their preferences or they may use CRM systems based on a teacher's recommendation. What is positive is the fact that many vendors offer CRM systems in free format or a cloud for education and testing. In many cases, it involves a registration, in order to determine e-mail contact and destination for using their software. Unfortunately, similar difficulties are also visible in seminars. This is a low level of orientation in information from Google. Some students have difficulty with advanced work in CRM system and know more about benefits and weakness of this solution.

Building on industry 4.0 and the new role of IT intelligences, e-learning becomes increasingly important. Work in enterprises and organizations will bring different situations and information technology will have an important place here. Students must precisely control their own IT skill with all spectrum possibilities. They will work with different information technologies; they will increasingly need good orientation skills for using automated processes. And e-learning has to support these needs based on intelligences and automated processes too.

4. E-LEARNING FOR OPERATING SYSTEMS AND CRM WITH AUTOMATED PROCESSES AND INTELLIGENCES

Automated processes and intelligences are well placed in information technology at public level and the same place is in operating systems and CRM. In this respect, e-learning needs to prepare students, such as IT users, to work with IT with a higher impact on intelligences and automated processes. Artificial intelligence and automated processes are dedicated to found solutions faster than people and bring more personalization and learning from the behaviour of IT users.

The artificial intelligence for the operating system is an idea of the intelligence for managing computer software and hardware for providing common service. It is the intelligence to solve existing difficulties (Rilwan Ul Haq et al. 2017) with memory, processes, file systems, network connectivity, and compatibility of implemented information systems. One example is the First Intelligent

Operating System (FiOS) with integrated artificial intelligence to perform tasks for IT users (AiroCorp 2019)

Artificial intelligence and automated processes also have many implementations in CRM. It is about better working with customers with the most sensitive approach and understanding for their needs. Intelligences and automated processes form the basis for modern sales and marketing efforts to develop and categorize the ever-increasing volume of customer and business signals and data. It is about how to help achieve a sustainable society with predictive scoring, forecasting, and recommendations. A list of tasks that play an important role in artificial intelligence and automated processes is shown in Table 1.

Table 1.

Artificial intelligence and automated processes in tasks for operating systems and CRM

Artificial intelligence and automated processed tasks	Integration into IT solutions
Operating systems	
an intelligent personal assistant (Braina) that allows to interact with computer using voice commands	Windows PC
smart knowledge navigator lets you send messages, schedule meetings and make phone calls	iOS
provide environmental observation services, especially people's behaviour at home	the household operating system
system for tracking package deliveries, find files on a computer and setting reminders	Windows
CRM systems	
account overview, leadership prioritization, automated data entry, personalization of ads	Salesforce, Zoho, HubSpot CRM
automated monitoring of marketing trends	Salesforce
chatbot designed to act as a digital assistant for individual consumers to help them find products, make recommendations, request a refund	SAP
natural language processing to classify whether the text of a message is emotionally positive or negative	Salesforce
optimizing the selling process based on client analysis to create guidance for close deals	Oracle, Zoho, SugarCRM
personalized marketing/experience through personalizing the content for customers	Oracle, SugarCRM, HubSpot CRM
predictive recommendations using a customer data that recommended products of greater interest	Oracle, Zoho

smart calendar to show information needed before the meeting	Salesforce
understanding social media conversations, product recommendations, image classification	Salesforce

Source: Own work

Intelligences and automated processes have the ability to perform many tasks such as: advising, assisting people when making decisions, considering conclusions, deriving solutions, interpreting input, monitoring, predicting results, and designing alternatives. Students also need to work with them in courses focused on operating systems and CRM to learn more about automation and implemented intelligence.

CONCLUSION

Sustainability is necessary for all aspects of life, and changes are visible to industry-based 4.0 processes with IT support. There is interest in adapting to current conditions with high detail sensitivity. It is about knowledge and a wide range of skills. Education and e-learning are responsible for the practical skills of students (IT users) to work with IT, from a basic method to complex processes based on intelligences and automated processes. The interest is in updating itself without impact on other activities and IT users, checking and finding facts in the background so that they may be viewed by IT users, or knowing about current issues and searching in the background an optimal solution. Operating systems offer an intelligent personal assistant and a smart knowledge navigator. CRM systems rely on a smart calendar, automated monitoring of marketing trends, personalized marketing, or lead prioritization. E-learning has optimal possibilities of bringing these IT capabilities to students based on practical work in selected operating and CRM systems to support a sustainable society through the diverse skills of IT users.

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IN THE DIGITAL SPACE: PROGRAMME DESIGN AND CASE IMPLEMENTATION

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Abstract. *This article discusses the structure of higher education teachers' IC competence. A system approach to IC competence formation is offered within the framework of higher education teachers' postgraduate education. A model of postgraduate education programme design is created and an example of its implementation in a course is provided. Based on the results of a completed pilot project in the Borys Grinchenko Kyiv University and within the framework of the international IRNet project (www.irnet.us.edu.pl) the effectiveness of the application of the approaches offered by the authors to teachers' postgraduate education to develop teachers' IC competence was confirmed.*

Keywords: Competence, Higher education institution, Postgraduate education, Pedagogical design

INTRODUCTION

Wide implementation of digital technologies is one of the conditions for higher education to come to the global level. According to European institutions' recommendations the competence approach concept is a basis for meaningful changes in providing correspondence of education with modern market demand

("DeSeCo", 2001). Because of the active use of digital technologies, digital competence (IC competence) is defined as a separate component ("UNESCO ICT Competency Framework for Teachers", 2018) as well as its derivatives including educators' digital competence framework DigCompEdu (Redecker, 2017). At the highest level, IC proficiencies result in innovation, individual transformation, and societal change (Hansen, Postmes, 2012). And digital competence is recognized by EU one of 8 key competences for fulfilling life and work ("DigComp 2.0", 2016).

The field of education requires new approaches and innovative pedagogical, information and communication technologies for lifelong learning. In a report of New Vision for Education ("New Vision for Education", 2016) 16 crucial proficiencies for education in the 21st century were specified for lifelong learning and 21st century skills development, including:

- Basic skills (required for solving everyday tasks) which comprise the following types of "literacy": 1. General, 2. Mathematical, 3. Scientific, 4. Computer,
  5. Financial, 6. Cultural;
- Competences (required for solving complex tasks and challenges), in particular: 7. Critical thinking, 8. Creativity, 9. Communication, 10. Collaboration;
- Personal characteristics (as a means of adaptation to social and technological changes): 11. Curiosity, 12. Initiative, 13. Persistence, 14. Adaptability,
  15. Leadership, 16. Social and cultural literacy and responsibility.

In the conditions of digital transformation (Bounfour, 2016), the educational system in the EU is modified within the framework "EU 2020 Strategy" ("Europe 2020", 2015). Digital teaching and learning are also considered within the framework of the strategic programme "Education and training 2020" ("Council conclusions on a strategic framework for European cooperation in education and training 2020", 2009). The questions of teachers' commitment to increasing their digital competence and methods of the process stimulation are taken into account there.

Therefore, the problem of the education quality supply arises, so that it is correspondent to European standards of teachers' professional competence level increase with the help of postgraduate education system.

The aim of the article is to offer an author's approach to the digital competence formation at the university and an example of its implementation in the process of postgraduate education organization.

1. INNOVATIVE MODEL OF TEACHERS' POSTGRADUATE EDUCATION

Nowadays the profession of higher education teacher is being considerably updated, as today it is not just addition to scientific qualification but functions as an autonomous and meaningfully independent professional unity. In the system of teachers' competences, IC competence is considered as a key one (Figure 1). However, an analysis of postgraduate education programmes discovered that teachers' IC competence formation has not got enough attention at modern higher education institutions.

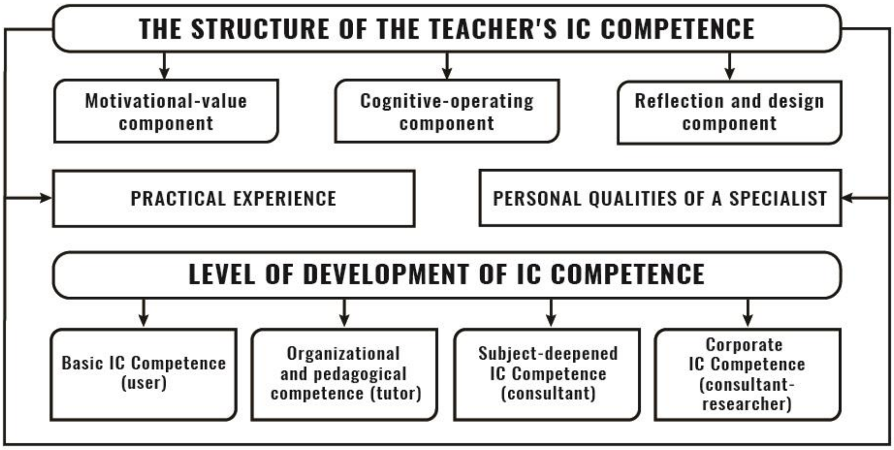

Figure 1. Structure of teacher's IC competence
Source: Own work

Usually teachers undergo postgraduate education to increase their level of professional competences. There are also courses dedicated to gaining technological literacy by teachers (Morze, Kuzminska, Liakh, 2017). However, the shift of emphasis from solving technological preparation tasks (mastering definite instruments and software) to innovative pedagogical technologies (project-based learning, distant and blended learning implementation, mobile learning, flipped learning) are the main tendencies of modern education. However, in most postgraduate education programmes in the sphere of digital technologies there are no modules aimed at moderators and tutors preparation as well as modules which provide training for teachers on pedagogical network interaction organization where a teacher could satisfy their educational needs including those for self-study, collaboration in network communities, teaching style design. Therefore, the content of DigCompEdu (Redecker, 2017) is defined by 3 groups of components which focus on different aspects of educators' professional activities:

Area 1. Professional Engagement: using digital technologies for communication, collaboration and professional development.

Area 2. Digital Resources: sourcing, creating and sharing digital resources.

Area 3. Teaching and Learning: managing and orchestrating the use of digital technologies in teaching and learning.

Area 4. Assessment: using digital technologies and strategies to enhance assessment.

Area 5. Empowering Learners: using digital technologies to enhance inclusion, personalisation and learners' active engagement.

Area 6. Facilitating Learners' Digital Competence: enabling learners to creatively and responsibly use digital technologies for information, communication, content creation, wellbeing and problem-solving.

One of the indicators for determining the expected learning outcomes of continuing education programmes was considered by the Education Technology Standards for Education and Training ("ISTE", 2016), including the standards for teachers (source: [online] at http://www.iste.org/standards/standards/for-educators).

To provide development of the abovementioned competences from the main trends defined in the report of NMC Horizon 2019 ("Horizon Report Preview. Higher Education Edition", 2019) the following ones were selected: blended learning designs, growing focus on measuring learning, advancing digital equity, rethinking the practice of teaching, increasing demand for digital learning experience and instructional design expertise, advancing cultures of innovation.

The authors of the article have developed a model for postgraduate education programme design in the part on teachers' IT competence (Figure 2).

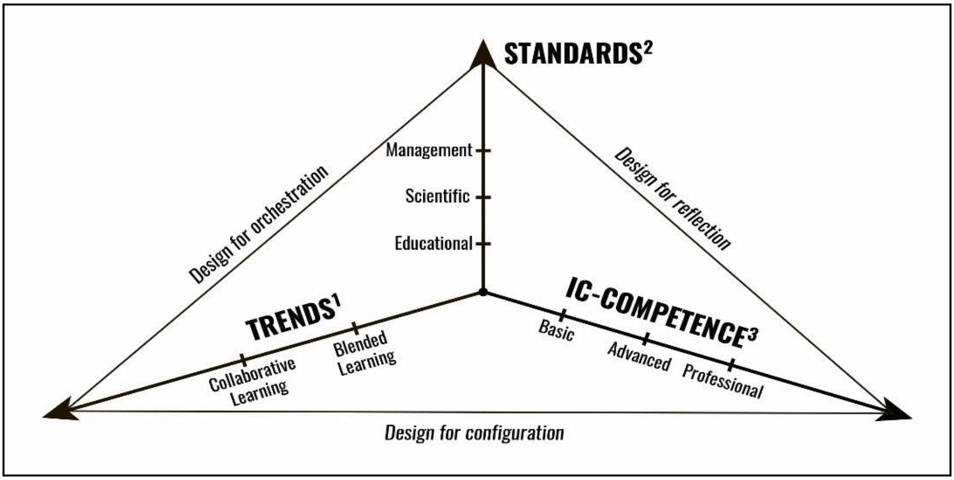

Figure 2. Model of teachers' postgraduate education programme design
Source: Own work

To define content modules of the postgraduate education programme it is offered to define:

(1) Educational trends and innovations (“Horizon Report Preview”, 2019, “NMC Horizon Report”, 2017). Using the NMC Horizon Report data it is possible to define trends which are currently important for an educational institution, make adjustments, carry out forward planning;

(2) The Standards and Guidelines for Quality Assurance in the European Higher Education Area (“ENQA”, 2012). In the standard of ENQA (European Association for Quality Assurance in Higher Education) the following indicators are defined: teaching (educational process, pedagogical activity); academic staff; educational programmes; facilities and resources, informational educational environment; education management; scientific research etc. It is possible to use corporate standards developed by a higher education institution on the basis of European recommendations, for example, a corporate standard scientific work of the university employees (http://kubg.edu.ua/informatsiya/naukovtsyam/dokumenti.html);

(3) *Competence level* (“UNESCO ICT Competency Framework for Teachers”, 2018, Redecker, 2017). In our opinion an advantage should be given to corporate standards of ICT competence.

Learning *forward-oriented* design for learning in technology-enhanced classrooms is based on several processes (Susan, 2016, Dimitriadis, Goodyear, 2013):

(1) *Design for configuration* – anticipating what students and other agents might configure to suit their specific needs, and preparing or equipping the design for such possible customization or modification (Figure 2).

(2) *Design for orchestration* – providing support for the teacher’s work at learn time (Figure 2).

(3) *Design for reflection* – ensuring that actionable data is gathered at learn time, to inform system evaluation (Figure 2).

(4) *Design for re-design* – designing originally with re-design in mind – with built-in support and flexibility so that re-design may be performed as easily and fluently as possible. It is carried out on the basis of a teacher’s attending certain modules or courses.

A system of postgraduate education can consist of both topical workshops (webinars) and separate modules or courses. Notably, a required condition is cumulative system of postgraduate education in continuous education system (Morze, Kuzminska, Liakh, 2017) that provides regular renewal of its content (Design for re-design) according to the level of both digital technologies and modern educational technologies development.

2. PEDAGOGICAL DESIGN OF COURSES AND AN EXAMPLE OF ITS IMPLEMENTATION

The ADDIE model was chosen as a model of pedagogical design of courses (modules, workshops) of postgraduate education system according to defined categories of learners and capability of e-environment. The ADDIE model is a framework that lists generic processes that instructional designers and training developers use. It represents a descriptive guideline for building effective training and performance support tools in five phases: Analysis, Design, Development, Implementation, Evaluation (Durak, Ataizi, 2016).

The analysis of the results of educational and scientific work of Borys Grinchenko Kyiv University teachers in 2016-2017 defined a need in design of the course "Development of educational, scientific collaboration and project management of ICT tools" (http://e-learning.kubg.edu.ua/course/view.php?id=2879). This course:

- covers major aspects of collaboration arrangement in education, evaluation and utilization for ICT tools in scientific communication, collaboration, scientific projects and research elaboration;
- meets current demand of the university on presenting the institution in scientific space (including creating profiles in scientific metric databases and scientific networks) and formation of project offers for scientific research realization both on local and international level that enables arrangement of joint scientific research in collaboration with leading European Union institutions;
- contributes to the formation of teachers' level of IC competence which corresponds to the *consultant-researcher level* (Figure 1) in the field of scientific work and project management (*Standards*, Figure 2) by means of collaborative learning experience enrichment (*Trends*, Figure 2).

Learners of the course, teachers who have at least basic level of IC competence according to the corporate standard of the university took the course distantly.

Collaborative learning has been studied extensively in educational research and found to be an effective distance learning strategy. Using own experience as a background and correspondence to personal educational requirements (in this case it was scientific communication arrangement and self-presentation as a scientist online) are the most effective baselines, the Community of Inquiry (COI) model was used on the stage of the course design process ("The Community of Inquiry", 2012) as its foundation. Each aspect of course design — *Social, Cognitive, and Teaching Presence* — can be considered and planned but must be interwoven when the course is taught (Kincannon, 2012).

As the implementation of COI models requires utilization of Wikis, Mashups like syndicated Personal learning environments, on the course development stage

LMS was used for creating an approximate action plan and development of IC competence (Figure 3). Self-study tasks are descriptions of real cases (for example, creation of a profile in ResearchGate and search for partners, consultants etc.) whose realization in social networks or the university wiki-portal requires a definite amount of preparation. For this purpose the following resources are used: LMS Moodle, communication tools (*Skype, Meet, Hangouts*), collaboration tools (*One Drive, Google Drive, OneNote*), international scientometric databases (*Web of Science, Scopus, EBSCO, Google Scholar*). And in order to provide assessment of learners' achievements in the course it is important to develop tests which ensure adequate quality according to the teachers' level (Kuzminska, Mazorchuk, 2016).

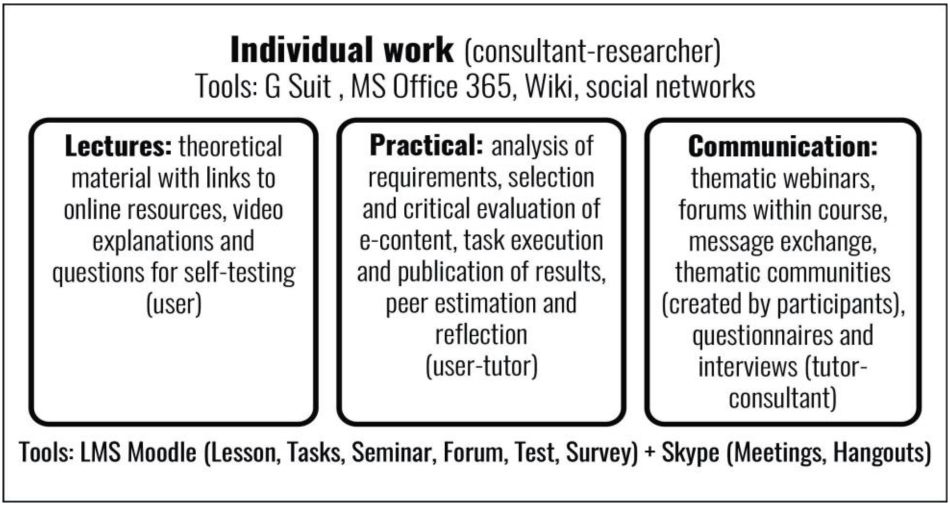

Figure 3. Structural model of acquiring competences through learning activities completion

Source: Own work

The implementation of the electronic course *"Development of educational, scientific collaboration and project management of ICT tools"* was carried out during 2017 at the Borys Grinchenko Kyiv University. 40 teachers took part in the testing of the course; 26 of them (group 1) were studying during 4 weeks with a carefully planned schedule and group activities. The content of the course, the training methods and the received result are provided in the article (Morze, Kuzminska, Liakh, 2017). The second group of participants (14 university teachers) was studying with flexible schedule taking into account their personal abilities. The difference between the groups was that collaboration of the first group of students was moderated by a course tutor and had a planned schedule.

In this research we reviewed the influence of COI model application on the quality of postgraduate education of teacher-tutors (Figure 1) based on the results of the two groups' participants survey with the help of Community of Inquiry

Survey Instrument (Arbaugh, 2008). The questions are combined according to three factors of influence: Teaching Presence, Social Presence, Cognitive Presence. Every question was evaluated on a five-point scale: 1- strongly disagree, 2-disagree, 3-neutral, 4 -agree, 5 - strongly agree. For each factor average values were calculated. Because the survey data have a normal distribution, the Student's T distribution was used to assess the significance of various mean values.

On the basis of statistical data processing (Table 1) an assumption can be made that the offered case of the COI model utilization obtained a positive appraisal. For the degree of variance f = 38 (n=40) critical value of Student t-test t_{score}= 2.024 (with the level of significance α = 0.05). The difference is statistically significant only in the case of evaluation of Social Presence factor which can be explained by different conditions of completing the course by different groups. Synchronized in time collaboration (reinforces Social Presence) is more productive for achieving professionally meaningful result (in our case involving colleagues into the projects, search for journals for publication of own research etc.).

Table 1.

Results of Self-efficacy student COI model

Factor	**1(26)**	**II (14)**	**Student t-test level (t)**	**Difference** (t_{score}-t)
Teaching Presence	4.67±0.05	4.55±0.11	0.74	1.284
Social Presence	4.17±0.11	3.64±0.13	3.11	-1.086
Cognitive Presence	4.47±0.09	4.46±0.14	1.84	1.964

Source: Own work

3. THE PRACTICE PREVALENCE: INTERNATIONAL EXPERIENCE

A similar course (module) was implemented for postgraduate education of an international team within the framework of IRNet project (www.irnet.us.edu.pl) that was carried out during 2018 by a team of international tutors (Figure 4).

80 teachers from 6 European universities (in Poland, the Czech Republic, Slovakia, Portugal, the Netherlands, Spain) and 4 non-European universities (in Australia, Ukraine, Russia) were involved in the learning process. Notably, the first group (30 teachers) were participants of the project who studied simultaneously, that is, their collaboration was moderated by the course tutor and had a planned schedule (similar to the first group of the pilot project that was carried out at Borys Grinchenko Kyiv University). The second group (50 people) consisted of teachers who registered on the MOOC by themselves.

As learning on the courses *"Development of educational, scientific collaboration and project management of ICT tools"* http://e-learning.kubg.edu.ua/course/view.php?id=2879) and *ICT-tools for e-learning* (https://el.us.edu.pl/irnet/course/view.php?id=2) was conducted using the same methodology, the analysis of the participants' reflection about the quality of postgraduate education by an authorial technique was carried out similarly with the help of *Community of Inquiry Survey Instrument*. For the degree of variance f = 78 (n=80) critical value of Student t-test t_{score}= 1.991 (with the level of significance $\alpha = 0.05$).

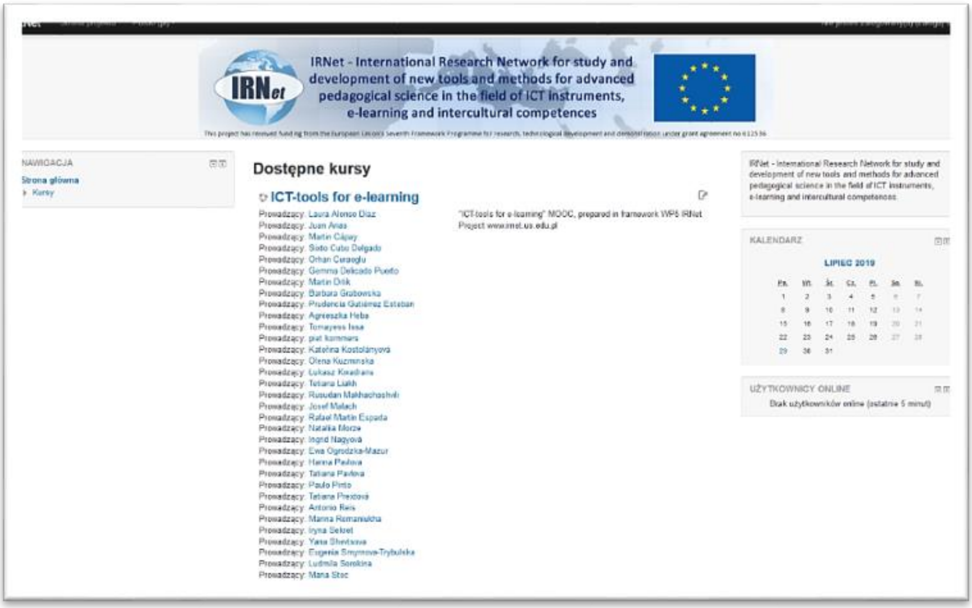

Figure 4. Description of the course on ICT-tools for e-learning (https://el.us.edu.pl/irnet/course/view.php?id=2)

Source: Own work

The COI model utilization obtained a positive appraisal (Table 2) for the course *ICT-tools for e-learning.* A statistically significant difference is observed in the case of evaluation of Social Presence factor (p=0.005135, p<0.05) similar to a Ukrainian pilot project (Table 1), which confirms the efficiency of synchronized in time collaboration (reinforces Social Presence) for achieving professionally meaningful result. However, unlike the pilot project there was also a difference in the case of Cognitive Presence factor (p=0.006026, p<0.05) which can be explained by a different level of the teachers' preparation to learn in the MOOC. The teachers of the second group (registered by themselves on the course) did not check their level of IC competence in advance and did not confirm being informed on the trends and the standards correspondence (Figure 2). In-depth interviews that were conducted with the participants of the course confirmed the assumption and discovered lack of motivation of the second group, whereas the participants of the project had a strong motivation for learning as it contributed to the project tasks fulfillment and recognition of its participants (Smyrnova-Trybulska, Morze, Kuzminska, 2019).

Table 2.

Results of Self-efficacy COI model of international students

Factor	**1(30)**	**II (50)**	**Student t-test level (t)**	**Difference** (t_{score}-t)
Teaching Presence	4.75±0.08	4.63±0.11	0.88	1.111
Social Presence	4.68±0.10	4.23±0.12	**2.88**	-0.889
Cognitive Presence	4.64±0.09	4.26±0.10	**2.82**	-0.829

Source: Own work

The obtained results will be taken into account when planning training in the framework of the following projects. One of these projects is project "One university - Many possibilities. Integrated programme within the framework of the POWER Programme of Ministry of Science and Higher Education, Poland, intended for academic staff and student communities of the University of Silesia. One of the tasks and modules of the project is E-LEARNING Training "Advanced ICT tools and methods for didactic activities: Moodle, Gamification, Digital Storytelling, Project-Based Learning, Inquiry-based learning, Flipped Classroom" (20 hours).

CONCLUSIONS

Lifelong learning which is a necessary condition for successful fulfillment of the modern individual in the conditions of a university is implemented through the system of teachers' postgraduate education. ICT competence is a key one in the system of professional competences of an academic teacher.

Development of ICT competence and skills of the 21st century in the process of postgraduate education is provided on condition that:

– An authorial design model of postgraduate education courses system is used;

– Using forward-oriented design for courses;

– Organizing distant learning by creating a COI researchers community;

– Monitoring of effectiveness of the utilization of offered approaches under permanent supervision.

Leading characteristics of teachers' learning success using the offered model rely on their own learning and professional experience, social presence and possibility of collaboration with others.

Positive self-evaluation dynamics of academics of Borys Grinchenko Kyiv University after fulfillment of the electronic course *"Development of educational, scientific collaboration and project management of ICT tools"* and after finishing similar module in MOOC "*ICT-tools for e-learning*" by the international team of teachers demonstrate the effectiveness of the authors' model and methodology of its fulfilment, and it can be recommended for implementation in teachers' postgraduate education system of higher education institutions.

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APPLICATION OF SUBJECT DOMAIN ONTOLOGIES IN E-LEARNING

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Abstract: *This paper presents an overview of two tools for e-learning developed in the Virtual Physical Space (ViPS). The first one refers to the generation of test questions. It is used in the course of education of students majoring in Software Engineering at the Faculty of Mathematics and Informatics (FMI) at the University of Plovdiv. The generation of the test questions is based on an ontology for UML, the processing of which is made by intelligent assistants. The second tool is called a Tourist Guide. It is intended to generate lessons in the area of cultural and historical heritage of Bulgaria in conformity with ontologies, which are created according to the CCO (Cataloguing Cultural Objects) standard.*

Keywords: e-learning, ontology, ViPS, test generation, tourist guide.

INTRODUCTION

Ontologies are formal structures that provide a common understanding of a particular domain. They represent domain semantics and allow intelligent access to information. Since the early nineties, ontologies have been a popular research topic in the field of artificial intelligence for natural language processing, knowledge presentation, and so on. With the introduction of the semantic web, ontologies are becoming more and more popular. Nowadays, the concept of ontology is also widespread in e-learning. The Semantic Web and ontologies are used in e-learning in a number of ways, such as for presenting knowledge in a given area, providing metadata for key concepts and subjects in a given field of study, facilitating the sharing of learning content, personalizing and recommending learning content, curriculum development, and training assessment (Kizilkaya, 2007). Most of the developed ontologies in the field of e-learning are learning task ontologies and subject domain ontologies.

The main purpose of this research is to demonstrate the use of subject domain ontologies in e-learning. The presented ontologies make it possible to create learning content that is structured by basic elements and semantic links between them. Such content can be reused and processed by intelligent applications, which can provide information to users and draw conclusions based on semantically structured information. In addition to knowledge in a particular field, ontologies can be used to gather information about users, such as what part of the knowledge in the ontology they have used, how many times they have used it, and others, which provides an opportunity to personalize the learning process. Two subject domain ontologies will be presented, one of which is used to generate tests in the given domain, and the other one is applied to present knowledge.

The structure of the article is as follows: It starts with the presentation of some research related to e-learning, followed by a brief description of the architecture of the Virtual Physical Space (ViPS) (Stoyanov, 2018), which adapts to e-learning. Next, two e-learning tools that use ontologies in ViPS are introduced. The first one of these tools is designed for the automatic generation of electronic tests (a Test Generation Environment), while the second tool is designed to generate electronic lessons in the form of routes for cultural and historical sites (a Tourist Guide). These routes can be used in e-learning as lessons in history, art history, geography, folk art, and many others.

1. RELATED WORKS

Ontologies in e-learning are used for different purposes. The authors of (Al-Yahya, 2015) provide a classification of ontologies used in e-learning:

– Curriculum Modelling and management. Curriculum elements are modelled to facilitate access and retrieval of curriculum information. This enables the curriculum developers to view the overall curriculum and ensure compliance with the vision and mission of the institution. It also provides a structure where learning units can be linked to outcomes and learning objectives.

- Describing learning domains from different perspectives, allowing for a richer description and retrieval of learning content:
  - Subject domain ontology (history, geography, programming, etc.).
  - Learning task ontology (lesson, activity, assessment item, simulation, exercise, LO, feedback).
- Describing learner data; this is useful for assessment and personalization. Personalization, according to the learner profile, may include sequencing the learning material, and tracking the learner performance:
  - Performance data (assessment data).

    - History data (units completed, etc.).

- Describing E-Learning services:
    - Providing a shared vocabulary for interoperability among various educational systems and the sharing and exchange of data among heterogeneous E-Learning systems.

The study shows that the highest percentage of ontologies in e-learning are used to present knowledge in a particular domain. An example subject-domain ontology is the “mobile computing ontology” (Sameh, 2009), which models conceptual elements in the mobile computing domain and the relationships between these elements. Another ontology is the “construction education ontology” (Raju, 2012), which provides a model of elements and relations in the field of construction education. Other examples include a Java programming ontology (Lee, 2005), which encompasses all concepts and features of the language construct and the relationship between objects. A manufacturing ontology (Bhattacharya, 2012) is used for knowledge representation of the various concepts and details of the products produced by manufacturers.

Task ontologies can be used to model various e-Learning tasks such as assessment, feedback, pedagogy design, search, and retrieval. In educational settings, in general, and in the process of learning, in particular, the assessment of students is an important task.

There are many tools that use ontologies to assess student knowledge. Ontology E-Learning (OeLe) is presented in (Litherland, 2013) and (Castellanos-Nieves, 2011). OeLe is an ontology-based assessment system, which automatically marks the students’ free-text answers to questions of a conceptual nature. It does this by mapping the student’s answer in the form of a concept map using a domain ontology. OeLe is a web-based system and the type of assessment items it supports include both closed (multiple choice) and open (text response) answers.

In (Al-Yahya, 2014) the authors use two domain ontologies – the SemQ and HistOnto ontologies. The SemQ ontology represents vocabulary (Arabic words from a specific domain), while the HistOnto ontology describes historical facts. A prototype, which accepts ontologies as input and provides Multiple Choice Questions as output is presented in (Papasalouros, 2008). The approach is based on strategies that use ontological axioms and inferred knowledge from OWL ontologies. Other works, in addition to the existing relationships in the ontology, also consider different ontology elements. That is the case of the work proposed by Cubric (Cubric, 2011), which along with relationships, also considers annotations and a semantic interpretation of the mapping between the domain ontology and the target question. The semantic interpretation is based on the notion of question templates that are founded on Bloom’s taxonomy of educational objectives (Bloom, 1956).

This paper presents the development of subject domain ontologies that intend to automatically generate test questions and present knowledge in the domain of cultural and historical sites in Bulgaria. Ontologies are developed as part of the Digital Library in ViPS.

2. ARCHITECTURE OF ViPS

The ViPS architecture is being developed as a major project at the Faculty of Mathematics and Informatics of the University of Plovdiv. It has been developed as a Cyber-Physical-Social Systems (CPSS) ecosystem (Sheth, 2013). The CPSS integrates various data originating from physical, cybernetic and social spaces through synthesis techniques to provide human-readable abstractions and conclusions. In this aspect the architecture has the following basic elements (Figure 1):

- Personal Assistants (PAs) – they operate as rational BDI agents and all their mental states are represented by events. They present the users in the space.
- The Ecosystem provides opportunities for the virtualization of real "things" taking into account the time, space and events. In this way, it is essential to propose appropriate formalisms for the presentation and work with the temporal, spatial, and event aspects of the things of interest.
- Operative Assistants (OAs), also implemented as rational BDI agents. OAs interact closely with services or micro-services to deliver the business functionality provided in the space.
- The last aspect concerns the integration between the virtual world and the physical world. We prefer to do this through a transparent intelligent layer of intelligent agents known as guards. The guards perform the data transfer from the physical world to the virtual space as well as information in the opposite direction from the virtual to the physical world. The IoT Nodes are configurations that typically include various types of sensors, controllers, and actuators located in dynamically constructed architectural layers. The communication between a guard and IoT Nodes is usually performed through the Internet and free personal network technology.

Two subspaces are presented in the architecture:

- Analytical Subspace – aiming to provide opportunities for time, space and events to work in a formal way;
- Digital Libraries Subspace – the aim of this subspace is to contain all the resources that are used by different OAs and PAs. According to the structure of the ViPS, the digital library subspace consists of two

elements – the Ontology Network (OntoNet) and the Domain Libraries (DoL). The OntoNet element comprises different ontologies in different domains. It is structured as a hierarchy of ontologies. The Domain Libraries are different resources, for example data bases, learning objects, and others.

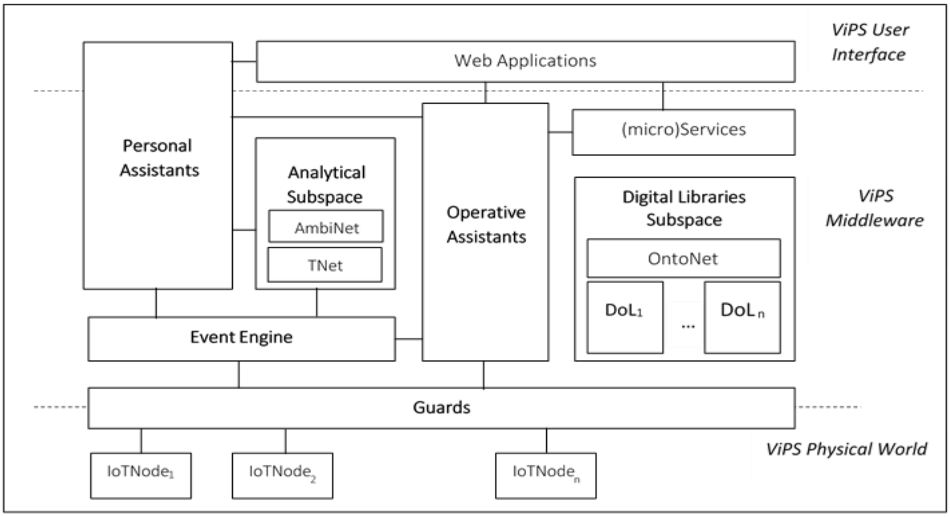

Figure 1. ViPS architecture
Source: Own work

The proposed ViPS architecture is also successfully applied in e-learning. A personal assistant for students named LISSA (Todorov, 2016) was developed, as well as specialized personal assistants for specific services in ViPS. The digital library has specialized resources such as test questions, SCORM-based learning content, and ontologies used by personal assistants or operational assistants to provide a variety of training services.

3. TEST GENERATION ENVIRONMENT

The automated test generation environment is intended for use in software engineering education. Its main task is to generate a test, to enable users to answer the questions and evaluate them by using a UML ontology (Unified Modelling Language).

The tests that are provided by the environment are made up of short answer questions, all of which are different. The functionality of the test environment is shown step by step in Figure 2, using an activity diagram. When the work of the environment starts, a test begins. Then the first question is generated and displayed for the user. The student has a limited time to answer each question, that is why when a question is displayed, a timer starts. It counts down the remaining time until the next question. The user has to type in his/her answer before the time is up. The question check is performed when the test-taker switches to the next question or when the time is up. When the answering of a question is completed, the system checks if that is the last one. If it is not the final question, a new one is generated and the whole procedure is repeated. When the answer of the last question is checked, the results are presented to the user to review the number of his/her correct and wrong answers. In addition, the questions with the wrong answers are displayed, so that students can analyse their knowledge and catch up on missed information. Figure 3 presents the graphical user interface of the environment with two types of questions – short answer questions and multiple choice ones.

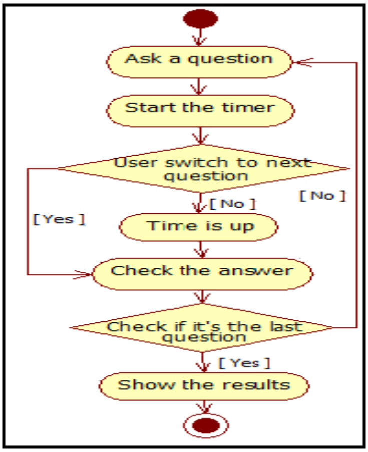

Figure 2. Activity diagram of the test environment functionality
Source: Own work

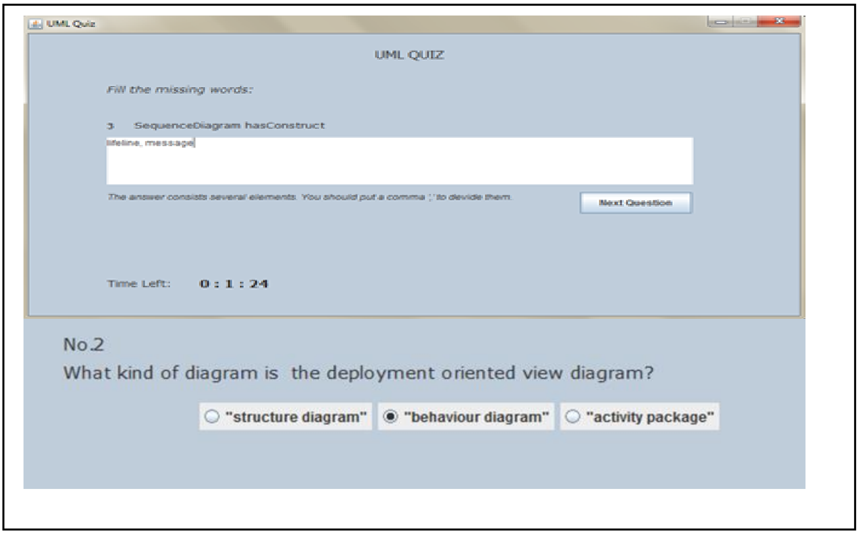

Figure 3. GUI of the Test Generation Environment
Source: Own work

3.1 Test Environment Architecture

The architecture of the environment consists of two components:

- Front-end component – a Graphical User Interface (GUI), which users use for communicating with the environment to do the UML test;
- Back-end component – Intelligent Agents (IA), which generate the tests, check the user's answers and analyse the results.

The intelligent agents, developed in the architecture of the test environment, are Operative Assistants in the architecture of ViPS. Figure 4 presents the architecture of the Test Environment. It is developed as a multi-agent system. The main components in its architecture are two OAs – a knowledge base and a database.

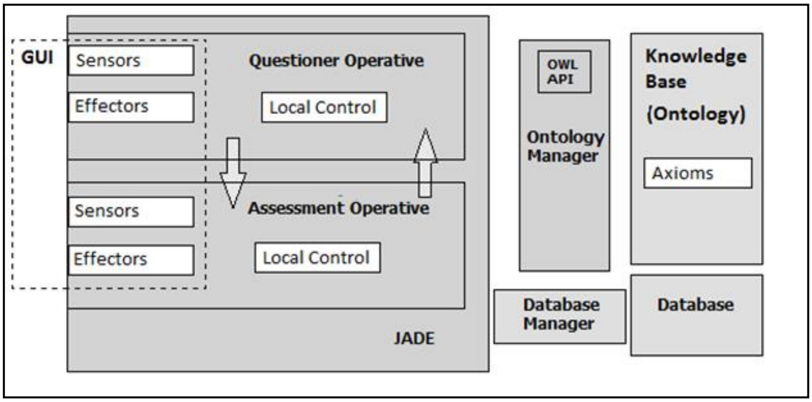

Figure 4. Architecture of the Test Environment
Source: Own work

The two operative assistants are the Question Operative (QO) and the Assessment Operative (AsO). Each of them has its own specific tasks, but their architecture is identical. They are realized as JADE agents (JADE), which process structured educational content (ontologies). Both agents are used by operatives to interact with their environment. They share a database, a knowledge base, and a graphical interface, and have their sensors and effectors, through which they access the Graphical User Interface (GUI). The sensors capture the environmental changes necessary for the agents' work. In case of changes, these are all external ones occurring in the graphical interface, caused by the actions of the user. The effectors aim to influence the environment and make changes in it. Each operative has its own local control, which is responsible for the coordination of the sensors and the effectors, as well as for its basic functions. It determines which effector/ behaviour is to be performed based on the available information received from the sensors or extracted from the knowledge base or the database.

The QO is the operative that generates the entire test. It forms the questions on a particular topic using an ontology. Through its sensors, it determines the start and end of the test and moves to the next question. The QO effectors are responsible for the presentation of the generated test questions and other information to the user. The most important behaviour of this agent is the Question Generator. It is a specific algorithm for the generation of test questions such as using axioms from an ontology. The role of the AsO is to check the users' responses to the questions and keep the information about them during the test. The operative has several behaviours that process, analyse, and evaluate the users' responses by using an ontology again. The agent's basic behaviours for these functionalities are the Answer Processor and the Assessment Service. The main theoretical model for generating questions and assessing them is presented in (Stancheva, 2017).

In addition to their specific functionalities, in order to perform and coordinate their tasks, the operatives have to communicate with each other during the test. This communication is realized in accordance with the FIPA standard. The QO and the AsO use asynchronous messages to communicate, when needed. The QO sends an informative message to the AsO, when the generation of the current test question is completed. In this way the AsO receives the needed information in order to check the answers of this question in the ontology. When the test is completed, the QO sends a request message to the AsO to obtain the results of the test when they are available. In response, the AsO sends the results and the necessary information to the QO.

An Ontology Manager Entity (OME) has been implemented to establish the connection between the operational assistants and the ontology in the knowledge base. Its function is to act as an interface between the agents and an ontology. It provides services that agents use when they need knowledge from an ontology. This includes loading one or more ontologies, extracting knowledge by predefined criteria, or confirming the authenticity of knowledge. The OME is implemented as a Java class that uses the OWL API as a library for accessing the OWL ontologies.

The database in the Test Generation Environment architecture is realized as a relational one. It stores data on test subjects and their results. A database manager (Database Manager) is implemented to access the database, used by the OAs to access, retrieve, and record data.

3.2 Knowledge Base of the Test Environment

The knowledge base of the test generating environment is an ontology developed for the syntax of the Unified Modelling Language. The main purpose of creating an ontology is to be used by the Operational Assistants QA and AsO to generate questions and evaluate them.

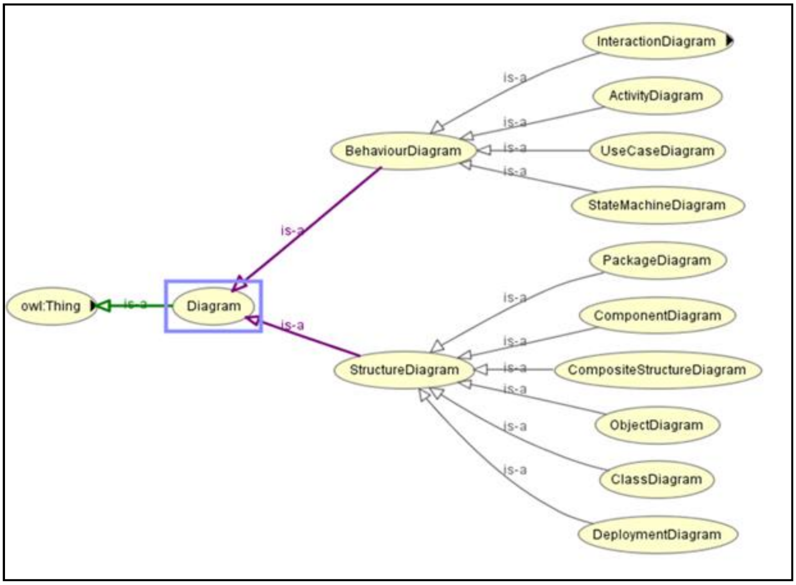

Figure 5. UML Ontology
Source: Own work

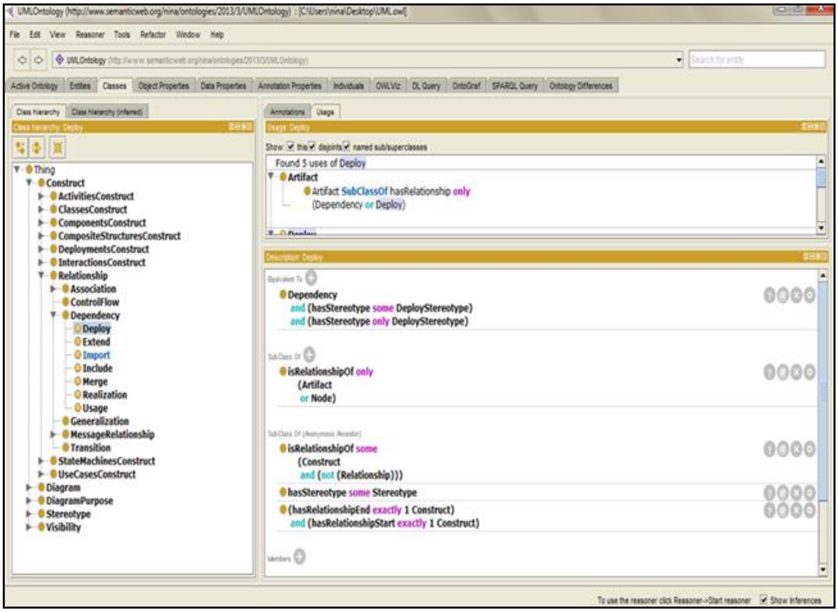

Figure 6. Dependencies for the Deploy class in a UML Ontology
Source: Own work

In the ontology, knowledge is presented about all the diagrams and elements that build UML. The concepts are described through a hierarchy of classes that are related to each other by property ("object property" or "data property").

In this way axioms are formed, which represent assertions about the UML language. Thus, information is stored not only symbolically, but also semantically, so it can be used not only as text for processing and visualization. We have concepts related to the meaning, which allow us to make conclusions about the truth of statements in the field. In Figure 5 there are shown some of the main classes in a UML ontology.

Each class of a UML ontology has its restrictions. They represent its relation to other classes or individuals through its properties. Thus, each class is semantically defined. Each subclass inherits all the restrictions of its super classes. Restrictions form anonymous (unnamed) classes in an ontology, which makes an ontology even richer and enables it to draw logical conclusions about individual concepts. Figure 6 shows the restrictions for the Deploy class.

The restrictions, created for the UML classes, belong to one of the following types: existential, universal, or cardinal. Existential restrictions ("some" or “some values from”) represent a relation through a property with at least one class. Universal restrictions ("only", "all values from") limit the relationship by a given property to be of a specified class only. Cardinal restrictions represent the number of connections.

Our ontology contains over 850 axioms so that it provides a variety of questions, which can be presented by the Test Environment.

4. TOURIST GUIDE

The Tourist Guide (TG) is intended to generate routes related to cultural and historical sites in accordance with the location and wishes of the users. The generated routes can be used for learning in different areas – history, geography, etc., in which case they can be called lessons.

The TG is realized as a specialized personal assistant in ViPS (Glushkova, 2018). To accomplish its main task, it uses the Cultural and Historical Heritage Ontology Network (CHH-OntoNet), which is a part of OntoNet in ViPS. The CHH-OntoNet contains a hierarchy of ontologies presenting different cultural, historical, and natural sites. The structure of ontologies is done according to the CCO standard (CCO). All new objects that are added to CHH-OntoNet comply with the standard. A major priority in the selection of cultural and historical sites for inclusion in CHH-OntoNet is that they are unique to Bulgaria. That is why we have chosen Bulgarian folklore for the first area and in particular Bulgarian Folklore Customs. We are currently working on more unique sites for Bulgaria such as Old Houses, Dialects in Bulgaria, and others.

The life cycle of the TG consists of the following steps:

- *User Questionnaire* – the TG interviews the user about his/ her interests. To conduct the questionnaire, all the questions asked are derived from the ontologies according to each user's responses;
- *Select Route Objects* – After the questionnaire, the TG determines which are the objects of interest to the user;
- *Route Generation* – the TG generates a virtual and a real route, and the user can choose from the two options.

The Tourist Guide is realized as a multi-agent system consisting of three operational assistants and one personal assistant. The operative assistants perform the tasks of user interviewing, generating routes, and retrieving information about cultural and historical sites from the ontologies. The personal assistant is responsible for presenting the information to the user.

4.1 CHH-OntoNet

The CHH-OntoNet consists of ten ontologies, nine of which describe a certain part of the cultural and historical heritage of Bulgaria: Subjects, FolkloreRegions, Costumes, Agents, Objects, Locations, Materials, Museums, and Expositions. These ontologies, as well as their knowledge, are structured in a way that meets the requirements of the CCO standard. There are ontologies corresponding to the dictionaries, defined in the standard, and others in line with the specific objects that are described.

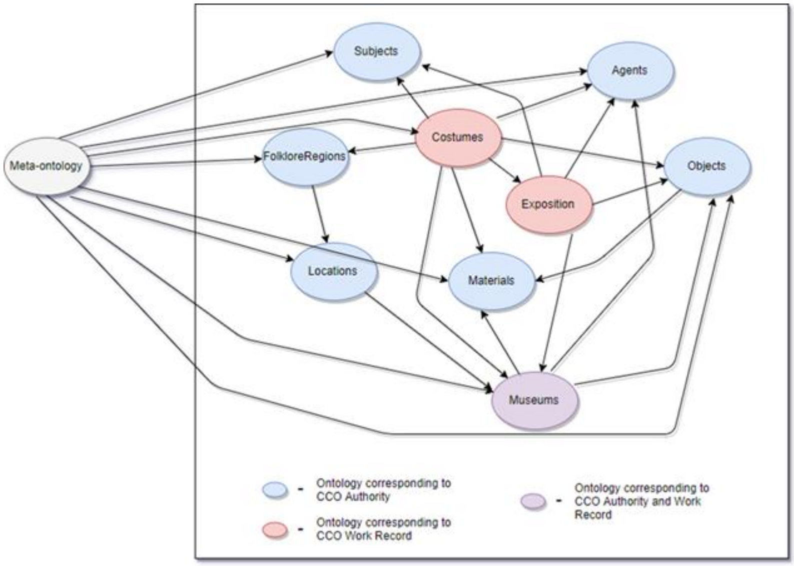

Figure 7. Ontologies in CHH-Onto-Net
Source: Own work

The distribution of knowledge in particular ontologies is very important. On the one hand, it is easy and convenient to compare the knowledge to the requirements of a standard. On the other hand, the separation of the domain of the cultural and historical heritage of Bulgaria into separate sub-domains allows effective, distributed maintenance and editing of the ontologies and knowledge in them. Separate ontologies can be upgraded and changed without influencing the others. Also, the addition of knowledge and new ontologies related to new objects is simple and it does not require to make changes to the structure of the others.

The objects of the cultural and historical heritage, such as traditional Bulgarian costumes, are usually placed in different expositions. At the same time, these expositions are located in specialized museums. This is a precondition for the development of additional ontologies containing knowledge about the expositions and museums.

In Figure 7 can be seen all the ontologies that have been created so far, as well as the relations between the knowledge in them. Each of the presented ontologies uses knowledge from other ontologies to describe some of the concepts. In this way, a network of interconnected concepts is created in separate ontologies. For example, Costumes in the Costume Ontology uses Objects (includes concepts such as types of clothing and their basic features), Materials (materials used in the manufacture of traditional costumes), and others.

The Meta-ontology is the only ontology that does not contain knowledge about the cultural and historical heritage of Bulgaria. It describes additional knowledge related to the other ontologies. This knowledge is used as a distributor by the operational agents to determine where and what to look for when they are creating a survey.

CONCLUSION

The development of ontologies in e-learning takes on an increasing role in the education process. The created ontologies provide great opportunities for facilitating the teachers' work, customizing learning resources, making it easier to search and organize the learning content, and automating student testing in a given area.

The article presents applications for presenting learning content in an interesting way, in the form of cultural and historical routes using the CHH-OntoNet, and for assessing students' knowledge by automatically generated and checked questions from a UML ontology. Both tools consist of a knowledge base in the form of ontologies developed with Protégé OWL (Protégé) and intelligent assistants developed as JADE agents.

Another operative assistant that is developed in the ViPS environment is intended to generate the structure of the learning content in the subject of software engineering according to specific criteria of the lecturer. For its purposes, it uses the Software Engineering Ontology that is located in the Digital Library of ViPS. The main idea is to link this ontology to the existing learning objects (SCO elements, pdf materials, lectures, etc.) in the Digital Library and the created structure of content to be filled with specific content.

As of today, the prototype of the Test Generation Environment has been used in a Master's degree program in Software Engineering at Plovdiv University with a small group of students. During their course of study, they used the Test Generation Environment for self-training in UML. At the course completion, the learners provided valuable feedback, expressing an opinion that the test environment was convenient to use, it helped them to prepare for the exam, but they would prefer to have a user interface in Bulgarian. That would be possible if we translated the UML ontology into Bulgarian; however, for the time being, we have developed it only in English. Last but not least, the students declared that the generated questions were not repeated. This is because the ontology is rich – it contains over 800 axioms, and test environment has a profile for each student that has used it. As far as the Tourist Guide prototype is concerned, it has not yet been experimented with in class, because we are still working on the CHH-OntoNet. The development of the cultural and historical heritage ontologies is a time-consuming process, which requires collaborative work of more people competent in this field.

New ontologies will be developed in the future to be used in eLearning in ViPS. In addition to ontologies for presenting a specific domain and for presenting tasks, we are considering the development of ontologies that will help to customize the electronic content.

Acknowledgements

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STEM-APPROACH TO THE TRANSFORMATION OF PEDAGOGICAL EDUCATION

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Abstract: *STEM-education is one of the important areas of the educational reform of XXI century. Modern initiatives in the field of STEM require the development of a model for transforming education that would correspond to contemporary demands of society. Such a general scenario and preliminary statement confirm the thesis underlying this research: there is a need to transform the existing model of training, first of all, pedagogical staff from classical education to innovative STEM-education. It was found that institutions and scholars are searching for new approaches to prepare people for solving real problems of the surrounding world through different STEM-approaches in education. In the article, the authors describe the transformation model of education for the introduction of the STEM-approach in a pedagogical university in order to prepare educators of a new formation and the main indicators of its effectiveness.*

Keywords: a model for transforming education, STEM-education, STEM-approach, STEM-practices, pedagogical university

INTRODUCTION

STEM-education is one of the most important areas of educational reform in the XXI century. The world of the XXI century involves competition at the global level, so countries have to invest a lot in STEM-education (Breiner et al. 2012, Kennedy, Odell 2014).

Modern digital technologies, STEM-technologies, which are becoming the foundation of an innovative economy, place new demands on staff at all levels:

- a request for qualified STEM-workers with practical skills in working with complex technological objects, with a new type of engineering thinking;
- a request for specialists with general STEM-literacy and general skills of problem-oriented thinking, that is, those who possess digital and social competences for the formulation and execution of the tasks in any and professional field.

All these requests over the last few years have been widely developing in connection with state and public attention to the IT-sector in Ukraine. Due to this attention the problems in education and staff training have been highlighted and discussed: the shortage of personnel for high-tech industries; low grades and poor knowledge of school graduates; the weakening of the natural-scientific and technical component of secondary education; weak professional orientation and the desire to master advanced technologies.

It is necessary that young people will be ready and would like to continue the STEM-career. Young people should understand that STEM is not fun and games; they must be ready to take on themselves the solution of the problems that arise in a constantly developing world. (Pittinsky, Diamante 2015).

These problems require not just the improvement of education, but also the search for new approaches for preparing people to solve real problems of the surrounding world. Therefore, nowadays more and more attention is focused on the so-called hybrid skills, when humanitarian and technical skills are equally well developed. To do this, it is necessary to train new generation teachers who are able to develop integrated STEM-skills for pupils and students. The teachers are constantly faced with new training strategies and techniques needed for successful STEM-learning and STEM-skills development. (Williams et al. 2015, Lund, Stains 2015). *As noted in* Williams et al., the concept of the STEM-approach varies greatly among educators, education researchers, curriculum developers and educational policy makers (Williams et al. 2015).

1. BACKGROUND

The STEM-approach is a wide range of actions, practices and techniques that are geared towards ensuring that society and humans will be ready for the future. These practices are only being developed today, and there is no definitive concept that would precisely and unambiguously determine the boundaries and frames of STEM-education. However, in recent years in different countries, a great deal of experience was received in the development of education in this direction. Reflection, analysis and special studies allow us to generalize and present the most significant characteristics of this approach.

The GoStem programme (https://www.go-stem.org [accessed 12 June 2019]) defines STEM as an educational approach based on the natural connection of four disciplines, and highlights its key principles: applied character to the real world problems; learning through problem solving and critical thinking; integration of different content. Based on empirical data it is confirmed that the engineering design process can be an effective way to promote and support the integration of concepts from several disciplines of STEM (Estapa and Tank 2017; Guzey et al. 2016). The edition (Moore et al. 2014) *defines the process* of engineering design as an important practice and the main disciplinary idea that students must master.

A number of conceptual approaches to integrated STEM-learning *were proposed* (Asunda and Mativo 2016; Kelley and Knowles 2016; English 2016). *According to* Bouwma-Gearhart and Milner, an interdisciplinary approach to pupils' learning and their immersion in the modern learning environment is a prerequisite for STEM-education (Bouwma-Gearhart 2014; Milner 2015).

The authors of (Stanford et al. 2016) *state* that the implementation of cross-links in STEM is a complicated procedure that obliges teachers to disclose the content of STEM-disciplines in the context of learning to solve real problems. Today, cross-links are recognized by many educational researchers, as there are clear results that inclusion of STEM-education can help learning of students to solve the tasks from life (Stanford et al. 2016).

Dalimonte *notes* that teaching how to solve problems in a global perspective is not as difficult as it might seem. Pollution, food production and energy are topics that can be explored through STEM-projects (Dalimonte 2013). STEM-education can help the next generation of students to solve real problems by applying concepts related to both disciplines and the development of critical thinking, cooperation and creativity (Burrows and Slater 2015, Roberts, 2013).

The STEM-approach in education focuses on new needs in staff resource and community development. For the education system, this is a question of the content and goals of modern education. The whole world is searching for this answer, offering different options.

Today, two main lines *can be identified* in the search for answers to this question: the development of STEM-literacy for all and the in-depth training of staff for high-tech industries.

The development of STEM-literacy for all

Providing each student with innovative thinking tools and experience in how to use mathematics, engineering and science to solve various professional tasks: the development of logic and thinking; the ability to set and solve tasks; the ability to investigate, analyze, prove; the teamwork, communication; the creativity; digital literacy.

The training of staff for high-tech industries

In-depth STEM-training of motivated senior pupils and students to enable them to succeed in science and technology: the motivation for engineering and technical specialties and careers in science and technology; access to laboratories where experiments are conducted and industrial tasks are solved for experience and practice; the absence of barriers to career and professional growth.

Two of these views on the development of the education system are not mutually exclusive but provide for different STEM-approaches and strategies for actions. In the case of emphasis on STEM-literacy, the review of the content and principles of the organization of education becomes the topical tasks for all. The emphasis on the training of highly trained staff draws attention to the organization of channels for access to the necessary knowledge, the elimination of barriers, the creation of additional conditions and the general interest in the scientifically and technically oriented sector of the economy. For the further development of STEM-education models at the level of the entire system, it is important to distinguish between processes such as training, functional literacy, learning and education in a narrow sense.

It can be said that at the level of conceptualization and development of the approach for appealing to STEM – this is first and foremost an indicator of the actualization of all alternative approaches and ideas in the field of pedagogy and education. The initiatives undertaken by different actors require an expansion and deepening view of the STEM-approach in education, acquaintance with *conceptual and practical* developments, and the development of *own model of the movement* of Ukrainian society and schools for new education based on the best world educational practices.

There are various practices aimed at the development of conceptual, methodological supporting of the STEM-approach in education:

- the organization of research, analysis of existing practices, their systematization and conceptualization (Morze, Smyrnova-Trybulska, Gladun 2018; Encouraging STEM studies. Labour Market Situation and Comparison of Practices Targeted at Young People in Different Member States 2015);
- the creation of pilot projects or experimental STEM-schools, where new methods are being approved and recommendations and methods for further dissemination, reproduction are being developed (Smyrnova-Trybulska, Morze, Zuziak, Gladun 2017; LaForce, Noble, King, Century, Blackwell, Holt, Ibrahim, Loo 2016);
- the development and approval of new educational subjects working in the interdisciplinary approach ("Technology", "Science", "Modeling"), the emphasis on problem-oriented craft and technologies, the development

and creation of products (Thorsteinsson, Olafsson, Autio 2012; Shmyger, Balyk 2017);

– the creation of the programmes for assessing the level of youth involvement in the STEM-sphere, the developing methods for assessing the effectiveness of national and local programmes (Stohlmann et al. 2012; Kelley, Knowles 2016).

2. RESULTS AND DISCUSSION

A model for transforming education to implement the STEM-approach was created at Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU) by scientists of the Department of Computer Science. This model has been approved during 2016-2018 at the Faculty of Physics and Mathematics and at scientist-research STEM-centre.

Summarizing the experience of the approval of the transformation model of education at TNPU through the implementation of the STEM-approach, we highlight the following most effective directions of action (Figure 1).

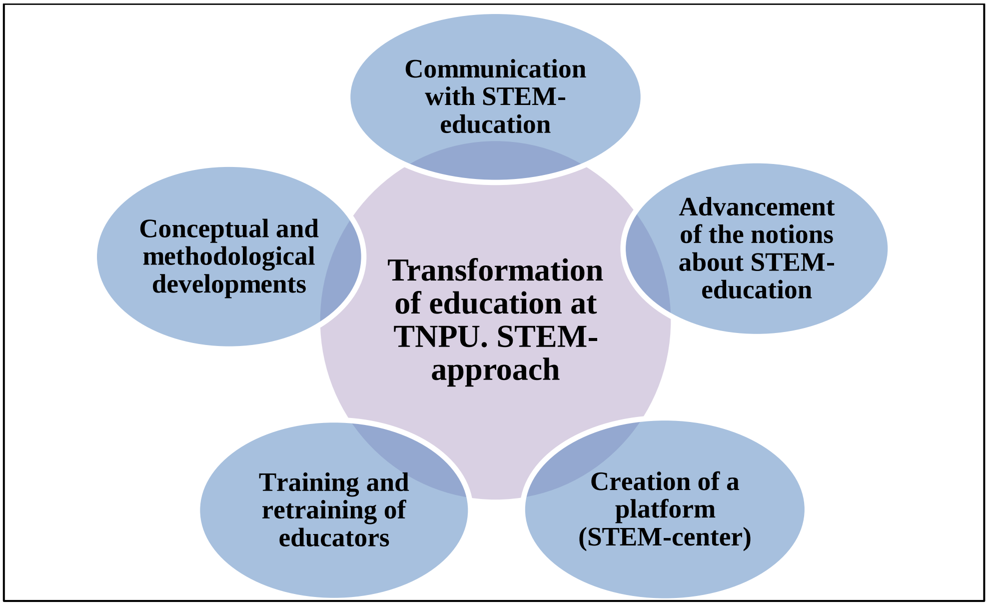

Figure 1. STEM-approach. Transformation model of education at TNPU
Source: *Own work*

1. Increase the intensity of communication on the topic of STEM-education. The content of this communication was determined by a wide range of issues that needed discussion, from simple acquaintance with those who work on this topic, practicing at different levels and in different fields, sharing experiences, problems and difficulties, and ending with communication regarding the new content of education, development of new programmer and concepts. Today the various formats of such communication are in demand: speeches, discussions about actual problems, the exchange of experience and the presentation of techniques, practices, working groups and joint projects.

Commonly, different subjects are involved in the promotion and implementation of the STEM-approach in education. These are government agencies and structures, local communities and self-government bodies, businesses and corporations, separate educational institutions and networks, public associations, professional communities and individual educators. Each of them chooses its strategy of action, based on the general situation, their interests and opportunities.

In the TNPU, for the creation and development of links between different actors, we took into account factors such as:

- building links between different educational institutions, academic and business entities to give pupils and students the opportunity to participate in internships and work on real projects, building effective communication: university – school – community – private companies – regional authorities;
- creating continuity in STEM-processes from school to university and to work place, increasing the applied value of choosing STEM-professions;
- organizing various events for active communication, sharing experiences and finding partners for joint activities;
- the creation of platforms and resource platforms, where new developments, models and samples are concentrated, and they become available for study and application;
- educational management, crowdfunding, sponsorship, fundraising, leadership in education.

The union with higher education, with the practice and industry of the city ensures the development of social responsibility, involvement of the university in solving the problems of the local community, provides a flexible and practical vocational guidance.

2. The promotion of STEM-education concepts among the general public and above all among parents, teens and other potentially interested individuals. This direction – providing public request and the demand for STEM-education. It is about clarifying the relevance of the engineering business, the scientific approach, the development of technologies and, together with them, the significance of the STEM complex for future quarries. This direction meant the exit in the media, on the platforms and parents' communities, the creation of special projects and initiatives in the field of PR.

One of such projects was the grant project "Popularization of STEM-professions", which was supported by the programme of the British Council "Active Citizens". Within the framework of the project there were organized interactive educational excursions, out-of-school schools, forums, festivals, STEM-workshops and other events, where a demonstration of new initiatives, achievements and perspectives in the development of STEM in the pedagogical university took place. STEM-excursions as a special type of integrated training sessions at the university have provided an opportunity to enhance pupils' motivation to STEM-disciplines through familiarization with real STEM-projects, for example, "3D printing of historic castles in Ternopil-land". The master classes provided the opportunity to create STEM-projects for pupils, useful for local communities, to develop their technological, career and life skills.

At the local level, the project "Popularization of STEM-professions" increased awareness of 7-11 grade pupils with such STEM-professions as an 3D-printing engineer, internet of things architect. As a result of the project, more than 300 pupils of general secondary education institutions of the city Ternopil and Ternopil region were involved in the selection of the future profession in the field of natural sciences and mathematics. This will allow in the future to increase the number of students by STEM-direction in higher education institutions of the Ternopil region and to train highly qualified specialists with STEM-skills that will be ready to solve modern innovation projects within the boundaries of the region and Ukraine as a whole. Conducting educational events aimed at the promoting the STEM-professions will enable to realize creative potential of young people to solve non-standard tasks, orienting on the needs of the community and its sustainable development.

3. The creation of a platform (STEM-center TNPU, http://stem.tnpu.edu.ua/), methodological hub as a place of gathering and constant exchange of experience, techniques and ideas. Because of the disparity of people and initiatives and of the lack of ready solutions in STEM-approach, it was necessary to create a platform for the functioning of separate STEM-components. Scientific-Research STEM-centre of the Faculty of Physics and Mathematics became a place for the emergence of initiatives, the development of individual projects and a permanent platform for communication of various stakeholders.

The resources for teaching STEM-disciplines in schools and at a pedagogical university have been aggregated in this centre, it is conducting the search for methods and approaches for implementing STEM, it is systemizing and accumulating different experiences of successful educational STEM-practices.

During the transformation of pedagogical education at the TNPU, such STEM-practices have been approved and implemented:

- *the cooperation with pilot STEM-schools*. Each such school has its own unique context, conditions of activity, principles, implementation of which characterizes STEM-education at the level of a separate school. The researchers of the Department of Computer Science at TNPU advise the leadership of individual schools on the implementation of the innovative model of STEM-education in their educational institution;
- *the effective career guidance among pupil and student youth*. The opportunity for young people to get acquainted with modern and perspective professions, to try themselves and to choose the own future profession;
- *the development of motivating platforms and formats* (scientific picnics, hackathon, Olympiads, contests, STEM-festivals, STEM-tours, STEM-workshops).

4. Training and retraining of teachers and practitioners involved in education. Most of the teachers received instruction only from one discipline (Honey et al. 2014). This poses a serious challenge for educators and administrators who are interested in the promoting of integrated STEM-learning. Therefore, the deployment of STEM-programmes requires retraining of educators and managers. For this aim, the STEM-teachers support programme was adopted at the university (the development of professional competence of educators, motivation, opportunities, successful experience) (Balyk, Shmyger 2018). At the Faculty of Physics and Mathematics there is organized the training of pedagogical STEM-personnel to increase teacher qualifications focusing on enhancing their professionalism in the field of STEM.

At the STEM-centre of TNPU there is pursued following:

- the creation of programmes (short-term and long-term) for training and retraining of pedagogical staff;
- the development of programmes, methodology and methodological materials for the staff of educational institutions on implementation of innovative learning technologies, case-study technologies, interactive methods of group learning, methodology for critical and system thinking development; the creation of pedagogical conditions for obtaining resultative individual experience of project activity and the development of start-ups;
- the internships and sharing of experiences, the inclusion of educators in networks and communities practicing STEM-education.

The result of retraining and advanced training is the development of STEM-education models for various educational levels, the creation of cases with scientific and methodological materials, cases for implementation of cross-cutting lines of STEM-subjects and for the development of STEM-lessons and excursions, the mastering of interactive teaching methodology, the developing of professional competences on STEM-based learning.

In the city of Ternopil there is a «School of New Formation Educators», which is conducted by teachers of the Department of Computer Science of TNPU. While working in the pedagogical workshops of the school, educators are studying STEM-education models for different educational levels, elements of STEM in different components of the education system. Studies and projects have their own forms and levels:

- in kindergarten and elementary school, the emphasis is on research the mastering of concepts and procedures that are related to scientific and research activities, and the research activity itself takes place in small groups;
- in secondary school serious attention is paid to preparing children for implementation of practical projects through real and training project activities in learning groups;
- in the high school, the core of the training is a practical project research activity that involves the inclusion of children in educational, research or professional projects run under the curatorship of university.

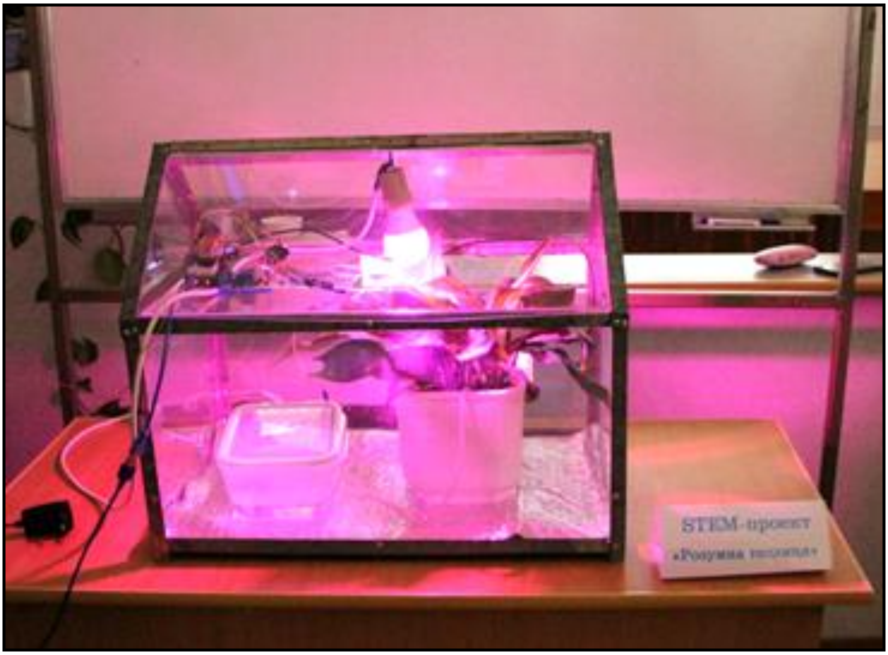

Figure 2. STEM-project «Smart greenhouse», created at the STEM-center of TNPU

Source: Own work

The importance was given to training in research practice, the inclusion of teachers in real research and engineering university projects such as «Smart greenhouse» (Figure 2), «Smart house» (Figure 3). These projects were created jointly by the teachers of the Department of Computer Science and students of the specialty «Informatics» for training in the creation of models of intelligent objects, their prototyping and research.

This means that retraining did not take place in a closed educational system, but was part of the collaboration with university scientists. The peculiarity of the practice was the involvement in the educational process of those who can include in their actions a practice and show how to do it.

Figure 3. STEM-project «Smart Home», created at the STEM-centre of TNPU

Source: Own work

5. Conceptual and methodological developments *of the transformation model of education in the direction of STEM*, the search for interdisciplinary content and methods of its transmission. This work was carried out by the teachers of the Department of Computer Science in interaction and coordination with the Institute of Education Content Modernization of the Ministry of Education and Science of Ukraine (Kyiv), the Ternopil Communal Methodological Centre for Scientific and Educational Innovations and Monitoring (Ternopil), the City Administration of Education and Science (Ternopil), the Regional Department of Education and Science, the Directorate of General Secondary Education Institutions of the United Territorial Communities.

The basic level of implementation of the STEM-approach in a pedagogical university is the planning of educational programmes, curricula and individual special courses. Let's highlight some important principles that we use to develop programmes of such special courses:

- the use of «open» tasks, allowing to search for solutions in various fields of knowledge; tasks and problems in which there are many solutions;
- the movement from the solution of practical and specific tasks to the concepts of a higher level of abstraction, ideas and theories (**Systems thinking**);
- the use to find a solution to the problem of the corresponding mathematical apparatus, focusing on arguments, proofs and logic;
- inclusion in the discussion and resolution of problems with the use of digital technologies (**Digital Technologies**), computational thinking (**Computational thinking**);
- the possibility of handmade organizing, conducting experiments; designing from improvised materials with the use of design-thinking (**Design thinking**), engineering design (**Engineering Design**);
- the teamwork organization, presentation of the received results before the group, discussion and mutual evaluation in the group (**Project management**).

A purposeful reformation and correction of educational programmes is carried out at the university. STEM-disciplines in one or another form are included in the programmes of specialties «Informatics», «Mathematics», «Physics», «Chemistry», «Biology», and in addition a programme for the development of digital entrepreneurial competences appears at the master's level.

In particular, university special courses such as «Design», «Design of thinking», «3D-modelling», «3D-printing», «Smart digital laboratories» etc. are taught. They refer to both the integration of knowledge from different fields and the development of student and masters' work practices over STEM-projects. These special courses are aimed at teaching students and teachers to solve real problems and are based on technologies. (Figure 4):

Consequently, the main characteristics of the transformation model of education at TNPU in the field of STEM are:

- the learning is built on problem solving (problem-based learning);
- the emphasis on "local" issues (rigorous learning), communication with external communities (external community);
- development of technological, career and life skills (career, technological and life skills).

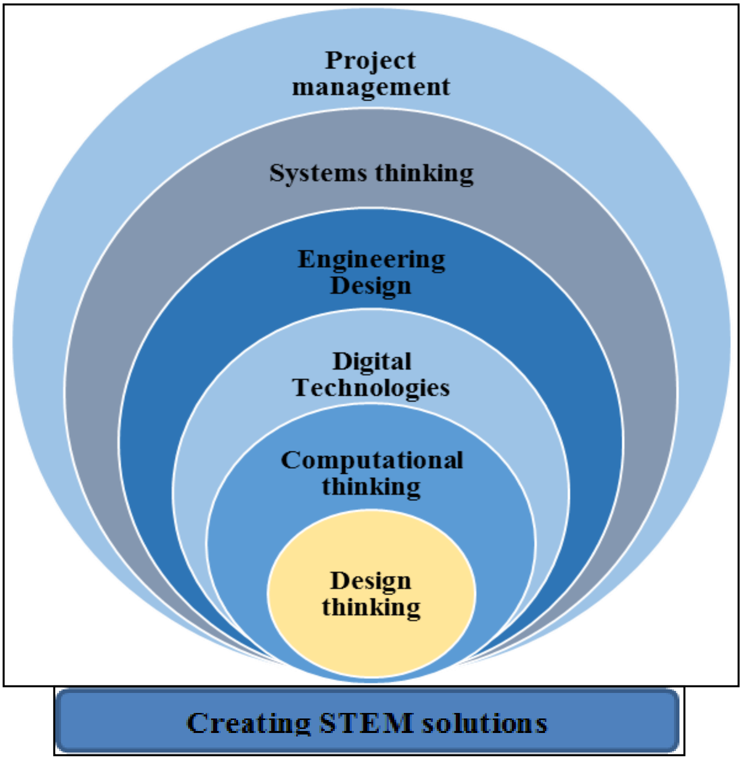

Figure 4. Technologies for solving problems in STEM-projects
Source: Own work

CONCLUSION

An overview of the state of STEM-education allows you to make some general conclusions. First, the intensity and diverse-plan of STEM-search can be seen as a vivid symptom of exigent transformations in education. It signals the inconsistency of the existing education system with either the innovation process or the challenges facing the individual in her individual development. Today, the STEM-approach is an area of active search, experimentation and innovation in education.

Secondly, in spite of the concentration on natural sciences, engineering and technology, the issue of STEM-education is a matter and problem of humanities–and social sciences, but first of all of methodology, management, organization of activities.

Third, STEM is the place for everyone. For the development of STEM-education, it is important to include a wide range of participants, each of which finds its own niche and its interest.

In the course of the study, the transformation model of education for the implementation of the STEM-approach in TNPU was approved, which included: increasing the intensity of communication on the topic of STEM-education, promoting the conceptions of STEM-education among the wide public, creating a scientific and research STEM-centre, conceptual and methodological developments of the transformation model of education in the direction of STEM, the training and retraining of educators and practitioners involved in education.

The main indicators of the transformation results of STEM-education at the university are: active participation of pupils, students, teachers in STEM-learning opportunities, interest in themes, concepts and practices of STEM, ability to participate productively in STEM-research processes, ability to apply relevant life and career skills, awareness of the STEM-professions, understanding the value of STEM in society.

In the future, the experience of educators in conducting research and development, the inclusion in the educational STEM-programmes of practitioners who possess these skills and have their own experience, going beyond the traditional teaching practices are relevant for the Ukrainian situation.

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CHAPTER II: E-LEARNING METHODOLOGY – IMPLEMENTATION AND EVALUATION

E-learning and STEM Education
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INTELLIGENT SCHOOL EDUCATIONAL ENVIRONMENT FOR DISTANCE AND BLENDED LEARNING

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Abstract: *The synergy between physical and virtual space determines the need to develop Cyber-Physical Spaces (CPS) systems that are used in all areas of life, including education. The Virtual Physical Space (ViPS) is an ecosystem of the Internet of Things that is being developed at the Distributed Learning Centre (DELC) Lab of the Plovdiv University in Bulgaria. The space is the successor to the e-learning environment DeLC, providing electronic learning materials and e-services for different groups of learners. ViPS is being developed as a reference architecture that can be adapted to various Cyber-Physical-Social-Space (CPSS) applications. The article will present an intelligent school educational multi-agent system called BLISS built on ViPS. As part of this system, we will present an electronic school diary based on Block chain technology, which will limit the ability to manipulate data sensitive to change. The goal of the system is to provide adequate and timely assistance and support to all participants in the learning process through specially developed personal assistants, while ensuring reliability and security of storing sensitive information.*

Keywords: Cyber-Physical Social Space, ViPS, IoT, Blockchain technology.

INTRODUCTION

Rapid development in all areas of life is based on the stormy progress of digital technology. They are becoming more sophisticated and integrated, and set the stage for a world where virtual and physical systems collaborate flexibly and globally. It is expected that the closely related Internet of Things (IoT), Cyber-Physical Systems (CPS), and Cyber-Physical Social Systems (CPSS) will play a significant role in the Fourth Industrial Revolution (Schwab, 2017). A "things" must have sensory, computational and processing capabilities that define it as an autonomous, proactive identity that can share knowledge and information with other surrounding "things" to plan and make decisions to achieve personal and common objectives.

Virtual Physical Space (ViPS) is an ecosystem of the Internet of Things that is being developed in the Lab of Distributed eLearning Center (DELC) of the Plovdiv University "Paisii Hilendarski". Because of its versatility, the reference architecture of ViPS enables it to be applied in various fields of application such as intelligent agriculture, tourism, smart cities, but also in education.

This article presents an intelligent multi-agency educational environment for the secondary school developed as a ViPS - adaptation. It briefly examines its evolution - originally developed as a distributed e-learning environment, expanded with the ability to take into account the physical world in which the learning process takes place, to a CPSS-type space.

The rest of the paper is organized as follows: a short review of ViPS as CPSS space is considered in Section 1. This section briefly presents the development of the e- learning system and the ViPS reference architecture. Section 2 presents BLISS as ViPS application in two parts – BLISS Server with personal assistants and BLISS School Diary. The final section briefly summarizes the current state of implementation and presents some ideas for the future extension of the application.

1. ViPS AS CYBER-PHYSICAL SOCIAL SPACE

The Internet of Things (IoT) paradigm allows every "thing" around us to exchange information at a higher semantic level - it is no longer simply a method of transporting messages, it is the basis for knowledge sharing. This paradigm can be applied to any dynamic CPS environment. By placing the user in the centre of such spaces, they become Cyber-Physical-Social Spaces (Wang, 2010). From a software architecture point of view, CPSS includes many components designed to provide effective support to different user groups, taking into account changes in the environment (Guo, 2015). Effective software models for building CPSS spaces support the creation of distributed, autonomous, contextually-sensitive, intelligent software. CPSS can be built for different areas, including education.

From DeLC to ViPS

DeLC (Distributed e-Learning Center) is the first e-learning platform developed by the DeLC Lab of the Plovdiv University. It aims to provide e-learning resources and services for different groups of students. The system is structured as a network of educational and specialized portals that exchange their services and resources. DeLC supports SCORM 2004 standard for creating, sharing and using electronic learning resources and QTI 2.1 for combined learning with electronic testing (Stoyanov, 2010). A school educational portal has been developed within the DeLC system (http://sou-brezovo.org). DeLC continues to be used to train students at the Faculty of Mathematics and Informatics of the Plovdiv University and of the different groups of students in Secondary School “Hristo Smirnenski”-Brezovo.

Although DeLC is a successful project, one of its main shortcomings is the lack of close integration of the virtual environment with the physical world where the learning process is de facto done. CPSS and IoT paradigms reveal completely new opportunities for taking into account the needs of disabled people, in our case disabled students. For these reasons, in the past few years, the DeLC system has been transformed into a Virtual Educational Space (VES), which functions as an ecosystem of the Internet of Things (Stoyanov, 2016). VES integrates the functionality of DeLC by adding a large number of additional services. This was made possible by the development of a system of intelligent components on which VES was built (Ivanova, 2017).

Personal Assistants play a special role in assisting the learning process, providing users with easy access to the space and services the system provides, regardless of the location of the user (Todorov, 2017). The component for representation of the user's location in the physical world was realized using a formal, Ambient-Oriented Modeling (AOM) approach. The use of this component is proven to help disadvantaged students (Glushkova, 2018)

Summing up the experience of constructing VES, we began to develop a reference architecture known as Virtual Physical Space -ViPS (Stoyanov, 2018) that can be adapted to different CPSS applications. An adaptation of ViPS is being developed for the secondary school. The current prototype of the BLISS environment (Brezovo's Learning Intelligent School System) is approved at the Secondary School "Hristo Smirnenski" in Brezovo.

1.1 ViPS architecture

ViPS architecture can be adapted to different CPSS applications. The essential aspects of ViPS are as follows:

- Users are in the focus of attention.
- Physical "things" are virtualized.

- Integration of the virtual and physical worlds.

ViPS architecture reflects and represents in the digital world an essentially identical model of the real physical world in which processes, users and knowledge of the area of interest, as well as the interaction between them, are realized in a dynamic, personalized and context-aware way (Figure 1). ViPS architecture is divided into two sub-spaces. The first is the Analytical Subspace that provides tools for the preparation of field-specific analyses supported by three modelling components:

- AmbiNet, which presents the spatial aspects of "things" and events that are modeled as ambients.
- TNet provides the opportunity to present and work with the time aspects of things. It is based on the official Interval Temporal Logics specification (Moszkowski, 1998).
- ENet - models different types of events and their arguments such as identification, conditions for occurrence and completion. It is essential to distinguish between three types of events - basic, system and domain-specific. Domain-specific events are realized as intelligent agents and they have proactive behaviors, ie when an event occurs, the agent is dynamically generated to represent it and send a message to the respective intelligent helpers (Guglev, 2017).

The second subspace of ViPS is Digital Libraries. They are implemented as open digital repositories. The OntoNet component is a hierarchy of ontologies that represents the essential characteristics and relationships of "things".

The main components in ViPS are the assistants, implemented as rational BDI agents (Wooldridge, 2009). We've made three types of assistants:

- Personal assistants (PA) that help users to work with the specific application.
- Operating Assistants (OA) - Typical intelligent agents located on the system server. They maintain access to the repositories and services located on the server.
- Guard Assistants (GA) - they provide an interface between the physical world and the virtual world.

Normally, for the creation of a new CPSS- application, we do not adapt the entire ViPS, but only its individual components. Thus, after each new application, the reference architecture is expanded and enriched with new functionalities.

Due to the nature of ViPS, users are placed in the spotlight, and due to the expected complexity of a CPSS- ecosystem, a GPA (Genetic Personal Assistant) has been developed to create a specific personal assistant for new users in the space. GPA manages, stores, and restores the personal assistant versions it has created in the past. The components that are adapted to develop BLISS from ViPS are: the genetic personal assistant, ENet, TNet and AmbiNet. New types of specific personal assistants have been developed.

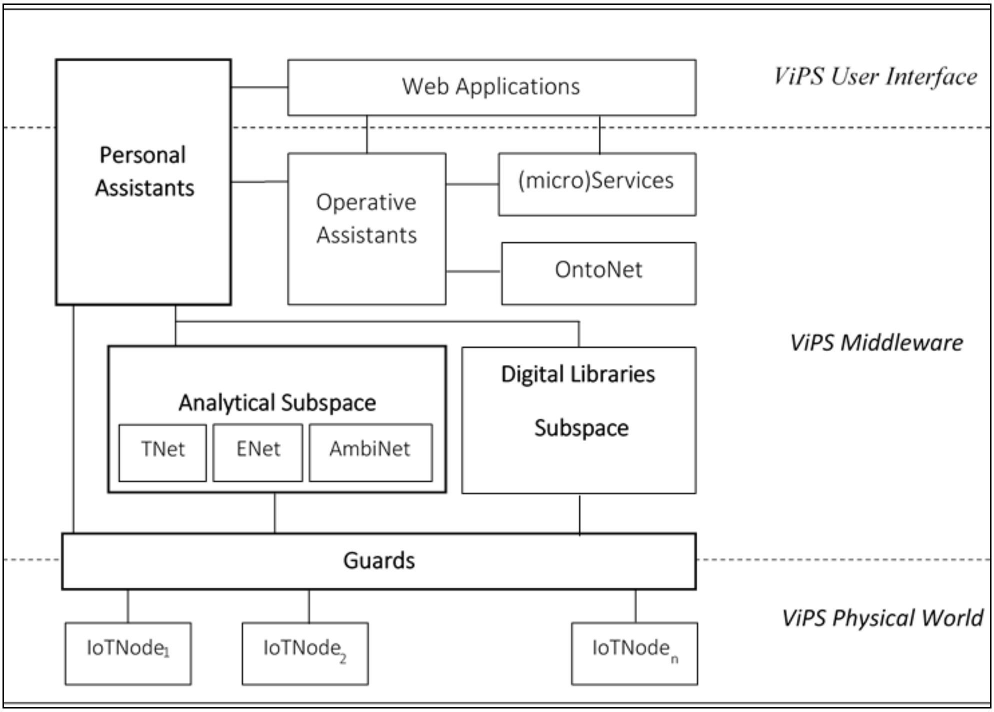

Figure 1. Architecture of ViPS
Source: Own work

2. BLISS AS ViPS APPLICATION

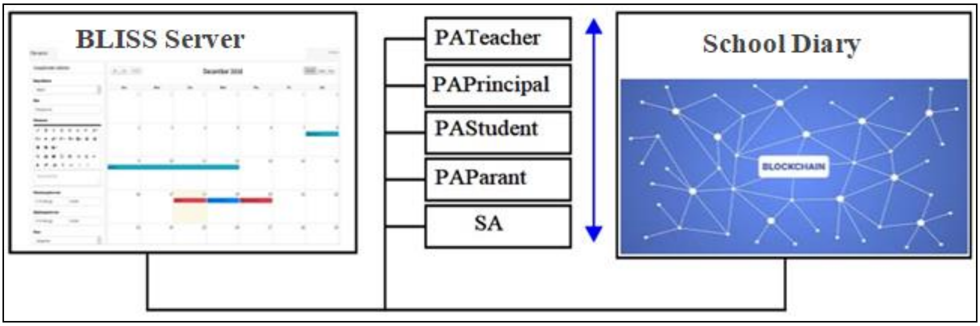

Figure 2. BLISS architecture
Source: Own work

BLISS is an adaptation of ViPS reference architecture to support the learning process in the secondary school. The system is accredited to work with students in a self-contained and blended form of secondary school education. BLISS (Figure 2) is implemented as a multi-agent system and includes two basic components. The first component of its core are Personal Assistants (PA). The second component is a school diary realized through blockchain technology.

2.1 BLISS Personal Assistants

The main task of the BLISS- personal assistants is to assist different user groups in fulfilling their specific functionalities.

PAStudent. A PA, assisting students to fulfil their daily duties in accordance with the established curriculum, informs about all upcoming events that concern it like exams, lessons, training sessions, consultations, and more. It monitors and reminds the student what they need to prepare before the upcoming event. For example, as the exam date approaches, the assistant begins to prompt the user to begin training, while at the same time can provide the necessary learning content in the form of electronic textbooks, SCORM e-lessons, training tests or links to external sources. The PA is able to prepare analyses of the results of the students's participation in the learning process. Figure 3 presents the interface for mobile device of the prototype developed PAStudent. It informs the student of all upcoming events. Event days are marked with a different color. Different colors indicate different types of events.

PATeacher. This assistant is intended for teachers. As in the case of PAStudent, it can also remind of upcoming events and the necessary preparation. Its main function, however, is to assist teachers to track and analyze the participation, outcomes and progress of their students' learning process. Analyses can be used for various improvements. For example, if the teacher notices that a large number of students have failed in a particular part of the exam but they also devoted considerable time to self-preparation on this topic, then PATeacher may conclude that the teacher may need to make some adjustments to the lessons, to ensure that it is easier for the students to learn.

PAPrincipal. The purpose of this assistant is to assist the school principal to effectively manage the school institution. The assistant is primarily intended to assist in planning, conducting and controlling the learning process. This is the most difficult to implement personal assistant.

PAParent. The aim of this assistant is to provide information to parents about the progress of their child at school. The parent can see information about the assessments, the events on its their child has to attend, and the notes made by the teachers. Due to the constant internal communication between the agents and the analysis of the information received by the student's PA, the parent can be warned of change in student behaviour. For example, if a child was an excellent student and started receiving lower grades, the parent would be warned about it. If the child ignores the recommendations he receives from his PA, then it will send a notification to the parent PA.

Figure 3. PAStudent visual interface
Source: Own work

All agents in the space have a common life cycle that is an adaptation of life cycle of a practical agent and is built up of four phases (Figure 4).

Registration Phase. To be eligible for a personal assistant, new users must sign up. The purpose of the registration is to generate a profile that is used to provide personalized help. In the current version of the account there is information about the user's personal identification, types of events that the personal assistant should respond to (for each event there is a type, a pre-notification time, and event information). When working with the system, the profile is updated.

Initialization Phase. Initialisation generates personal agent wishes (create_PC). In this case, the role of the wishes is played by a personal calendar representing the user's participation in the learning process for a certain period (term, school year). The generated personal calendar is stored in a storage database on the server and a copy thereof is sent to the person's device assistant to the user. Every update by a mobile agent is also reflected on a server data base, so that it is possible to completely restore the personalized assistant to a particular user if needed. Apart from this, the assistant can also be used in parallel on several devices without this interfering with his work.

```
/* Registration */
B0 ← get_percept;
profile ← register(B0, student_id);

/* Initialization */
Desires ← create_PC(profile, B0);
B ← B0;
I ← I0;

/* Deliberation */
while true do
          percept ← get_percept;
          B ← update(B, percept);
          D ← identify_goal(B, Desires);
          I ← compose_goal(B, D, I);

/* Planning */
          π ← plan(B, I, Ac);

          while not (empty(π) or succeeded(I, B) or impossible(I, B)) do
                    α ← head(π); execute(α); π ← tail(π);
                    percept ← get_percept;
                    B ← update(B, percept);
                    if reconsider(I, B) then
                    Desires ← update(B, I, Desires);
                    if needed then update(profile);
                    break; // go to external while cycle
                    end-if
          end-while
end-while.
```

Figure 4. PA Life Cycle
Source: Own work

Deliberation Phase. At this stage of the life cycle, the immediate goal (I) should be defined - to which event the user will be targeting. The goal represented as a domain event is identified by searching (identi_goal) in the personal calendar depending on the beliefs (B) of an assistant. In some cases, the assistant needs to respond to more than one goal, that is, to compile a composite goal (compose_goal).

Phase planning. Once this goal has been determined, the agent must prepare a plan to achieve it. In some cases, it is necessary to reconsider the objective (reconsider) . This usually requires updating of the assistant's environmental information, with the goal of identifying what updating is required in a student's personal calendar or profile before defining a new goal.

The around environment of assistants consists of BLISS Server and School Diary. In the BLISS Server, all information objects (such as schedules, lessons, exams, consultation, self-preparation, meetings) are presented as Domain-specific events. Authorized teachers supported by the server can create, update, and remove events. The server stores these events, controls access to them, and provides them with the personal assistant to students to generate, manage, and control customized curricula and schedules. Any change to the server is automatically perceived by the all "interested" assistants.

The BLISS Server prototype allows to manage all the information on the server. Figure 5. shows the server application menu with its main functionalities.

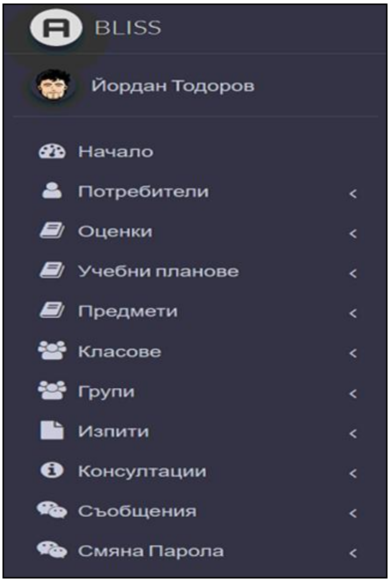

Figure 5. BLISS server menu
Source: Own work

The School Diary, implemented with the help of Blockchain Technology, is also located in the assistant's environment. In essence, the electronic School Diary is a multi-agency system in which assistants with different rights and roles communicate and coordinate their activities.

2.2 BLISS School Diary

BLISS School Diary is developed using hybrid technology. Blockchain technologies succeed in achieving integrity and trust in a clean peer-to-peer (P2P) system that consists of an unknown number of peers of unknown reliability. P2P architecture is a distributed software system that consists of nodes, all of which have only functional capability and responsibility. Participants (nodes) exchange information and assets with each other. They work together with the help of a communication environment to achieve a goal without having a central element of coordination and control. A key role in building and maintaining the chain of blocks is the use of cryptographic security technologies. Blockchain technology is based on a distributed system of records (ledgers) that support property information and store the entire history of transaction data in the chain. Each node has its own copy of the register, allowing the individual nodes to collectively and sequentially identify the ownership through the blockchain algorithm.

The block chain uses a public-private approach to asymmetric cryptography, which is the basis for identifying users, transferring ownership, and protecting against unauthorized access to the system. The purpose of the block chain is to store vast amounts of data and to remain unchanged after their creation or attempting to manipulate these changes to be discovered very quickly and easily (Guy, 2017). Ensuring security and the rapid identification of attempts to manipulate data can be successfully applied in the development of an electronic School Diary (Seyoung, 2017)

Block chains are public and private depending on ownership. Public ones are "open": they are open source and no inclusion rights are required. Private block chains are owned by a separate organization. As can be seen, they are "closed" and not every Internet user can join them and add transactions. For the development of "School Diary" we use a private block chain. Nodes in the system will be all the teachers and the director of the respective school. Each teacher sends a request to the school principal to become a node in the system. Once access is enabled, the system provides a public and private key to the teacher, through which he can check and sign the transactions in the e- diary. At the end of each day, one block will be validated in the block chain where all the transactions for that day will be completed. The blocks will be of varying size each day, depending on the number of transactions.

For the purposes of this development, we define four kinds of roles of system participants that are described in the BLISS module- students, teachers, school principal and parents. Each role belongs to a group of users who have the same functionality and rights. For each of the roles, genetic personal assistants are developed to assist users with the system.

The goal we have set is on the one hand to record the change-sensitive content that will remain unchanged over time using a block chain and, on the other hand, as using all of the benefits of the Data Module (DM). We will use both approaches to building an electronic School Diary. For a link between the block chain and the DM we will place an operative specialist assistant (SA) which is an intelligent agent and is committed to responding to the environmental change of the electronic diary. Upon a block chain change, as a validation of a new transaction block, SA responds and informs all assistants concerned about this change and simultaneously writes the information into the data module on the server. Each teacher introduces the appraisals of the students concerned as separate transactions in the block chain, signing them with his or her respective private key. Students are not nodes in the system, and the recipient of the transactions will be the school principal.

Once transactions have been signed, the block chain checks them for formal and semantic correctness and authorization. Only the correct transactions are completed in a block at the end of the day and validated in the block chain, updating all the registers in the system. Upon adding a new block to a chain, SA responds to changing its environment by sending the information to the corresponding PAStudent and PAParent for the change. Once the personal assistants inform the users, they record the grade in the student's notebook. Every personal assistant remembers as what it is created. It stores the information received in its knowledge base and monitors the progress of the individual student.

As already mentioned, the VIPS domain events are realized as intelligent agents. For example, if there is a notice of an upcoming event (Exam) L1 = <Mathematics, Exam, attr (20.05.2019, time (10: 00,10: 45))>, PAStudent not only informs the user, but also to be in a state of pre-emptive action and prevention, ie having a preventive interval based on its knowledge base for this type of events. For example the preventive interval is 15 days and PA has to draw up a plan to help the student to participate in the event and to achieve the goal. It can provide student with the necessary resources for self-preparation and assists him in the learning process. Information resources in ViPS are stored in digital libraries that are open to storage with different information - electronic content, test questions, and more. For intelligent search and support of the use of information, a meta-level, implemented as interrelated ontologies, is developed in ViPS. Libraries are served by specialized operational assistants, realized as BDI rational agents. Also, PAStudent may offer other resources provided by the teacher for self-preparation.

The School Diary allows for the realization of other BLISS features. Once the student has successfully completed the appropriate education level, the School Diary may initiate the student's diploma by connecting with another block circuit that allows the transfer and tracking of Factory-Numbered Documents (FND) in the school. Our idea is to build a private block chain between the Ministry of Education and Science, the Publishing for Factory-Numbered Documents; the Regional Management of Education (RME)-Plovdiv and other schools, and thus provide a secure way to process and transfer documents with factory numbers. Each individual organization will be a separate node in the system, such as:

- Each school sends a request to become a node in the system to the RME - Plovdiv. Once access is enabled, the system provides a public and private key to the relevant director through which it can check and sign the transactions for receiving and sending the factory-numbered documents.
- The Publisher prints the documents and introduces FND as assets in the system and sends them on the basis of the preliminary applications to the respective schools.
- The Director checks and accepts the transactions by signing them with their own private key received by the system.

Once the documents become assets in the school's portfolio, they can go through different states. An asset can be passed to another organization, it can be used or scrapped. The block chain checks every transaction for formal and semantic correctness and authorization. Only correct transactions are recorded and completed in a block at the end of the day and validated in the block-chain. In this way, each node will have its own copy of the entire history of transactions that occurred in the system. This allows us to track the movement of all factory-numbered documents ever created in the system and to guarantee their origin.

CONCLUSION

The dynamics of social development in recent years and the requirements imposed by the Fourth Industrial Revolution determine the need for lifelong learning inclusive and continuing training. There are a lots poorly educated or under-qualified people from ethnic groups in Bulgaria that are returning to secondary school. It is essential for them to have intelligent assistants and environments to support them in their learning process. The first prototype of BLISS is tested at Secondary School "Hristo Smirnenski", Brezovo. PAStudent is fully implemented, and the other aides are in the process of being developed. We have successfully implemented a block chain using Etherium's open-source technology, which is being tested at this stage. More than 40 students who study on individual plans use and test their personal assistant. The learning outcomes of the previous school year are very good. All students are motivated to continue their education using the developed environment.

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HOW TO CREATE AN EFFECTIVE FLIPPED LEARNING SEQUENCE IN HIGHER EDUCATION

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Abstract: *This article shows peculiarities and tendencies of flipped learning implementation in the educational process of higher educational institutions, describes the model of flipped learning implementation using e-learning courses. The authors present the results of the survey conducted within the framework of the international project Erasmus + MoPED on flipped learning, participated by bachelor's and master's degree students of the Borys Grinchenko Kyiv University. The article includes an example of a flipped learning sequence based on intended learning outcomes and Bloom's taxonomy. The example provides a list of students' activities, including assessment, and their distribution among the phases of flipped learning sequence: Pre-Phase, Face-To-Face Phase and Post Phase.*

Keywords: flipped learning; educational video; Bloom's taxonomy; intended learning outcomes (ILOs); higher education.

INTRODUCTION

Transformation of society under the influence of digital technologies, change of the labour market requirements to specialists and their competences, peculiarities of modern students' needs in knowledge acquisition sources and methods, practice-oriented learning, dual education system, combining study and field experience require immediate changes in higher education, including changes of educational process organizing and utilization of innovative pedagogical technologies. One of the ways to provide those changes is the implementation of e-learning and distant learning technologies; the development of e-learning courses and other types of e-learning content; standardization in e-learning content and electronic educational environments development and a global shift from Learning Management System (LMS) to Training Management System (TMS) (Morze, Buinytska, Varchenko-Trotsenko 2016).

Today many educational resources in electronic format placed in the public domain can be divided into two groups: developed learning content and services for content development. Designed scenarios for educational videos, visualizations and presentations sets of questions and tasks can be included to content. Services allow using models for content design, that is a service is a “wrapping” which “wraps” some content for an end user; e-learning courses can be included there. There are open questions left: for which services do we need to create content, which technologies should be used in the process to increase students’ positive motivation for learning and ensure quality of their learning?

Recently, the concept of teaching in higher educational institution has been changing from teaching aimed at theoretical materials exploration where a teacher is the main source of information to practice-oriented teaching, students’ active involvement in educational process where their needs and peculiarities of teaching z-generation students are considered, which manifests itself in the use of digital technologies and devices as well as different cognitive learning styles. The present labour market sets for higher education the task to train a modern, creative, mobile graduate who has a complex of occupational key competences and is ready to effectively perform their professional activities in the conditions of globalization and informatization of all spheres of the society. The educational process in a modern higher educational institution has to be built on the basis of the use of innovative pedagogical technologies, in particular ICT. These technologies include flipped learning, blended learning, gamification, adaptive learning, microlearning, etc. (NMC Horizon Report, 2018).

That is why in the Borys Grinchenko Kyiv University a lot of attention is paid to e-learning implementation based on the use of electronic content (e-content) including e-learning courses (ELC) and electronic collaboration (e-collaboration) technologies on the basis of the University’s designed electronic informational learning environment. The problem that arises is integration of innovative pedagogical technologies with e-learning courses. One of the above-mentioned technologies is flipped learning based on using video materials of new format.

Flipped learning technology has become one of the innovative educational strategies in recent years. It “turns around” direct teaching of disciplines and helps to focus on attracting students’ interest to applying gained knowledge and high level of thinking skills formation (Bloom, 1994).

The purpose of the article is to develop a model of flipped learning technologies implementation on the basis of e-learning course utilization.

Methods

To achieve the goal, a number of methods were used, in particular theoretical ones: methods of systematic and comparative analysis of scientific sources, methodological literature, and special literature to find out the elaboration of the problem of implementing flipped learning in the educational process of higher educational institutions; synthesis and generalization for the formulation of the main provisions of the study; empirical – a survey and interviews with students of pedagogical specialties. In particular, at the Borys Grinchenko Kyiv University, in July 2019 a survey was conducted, in which 76 participants took part, including 12 bachelor's degree students and 64 master's degree students. The survey was passed by students of 5 specialties of pedagogical direction from the Faculty of Information Technologies and Management and Pedagogical Institute (Figure 1). The survey was conducted (https://docs.google.com/spreadsheets/d/1KT2m6MUs8vX9cSIAy5J1HYHGuKe2amRDLisTxEieO7A/edit?usp=sharing), where questions about the fields of study were raised.

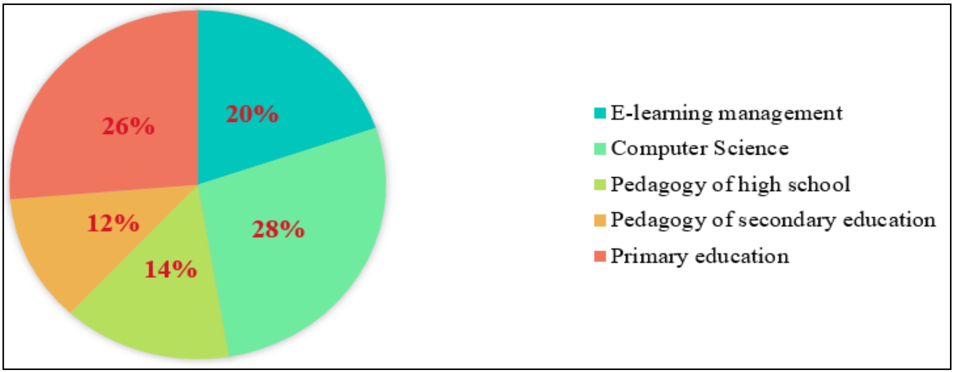

Figure 1. Fields of study of the students who took part in the survey

Source: Own work

1. THEORETICAL PECULIARITIES OF FLIPPED LEARNING

1.1. What is "flipped learning"?

Although there is no single model (Tucker 2012), the flipped learning is characterized in terms of course structure: instructional content (e.g., pre-recorded class lectures) is assigned as homework before coming to the class. In-class time is then spent working on problems, advancing concepts and engaging in collaborative learning (Findlay-Thompson and Mombourquette 2014). Removing the instructional content from in-class time allows the instructor to spend more time on personal engagement of every individual student (Roehl et al. 2013), but perhaps equally important, the flipped classroom model is student-centered (McLaughlin et al. 2014), which means that students are responsible for watching lectures on their own and coming to class prepared for in-class activities and discussion. Little direct evidence currently exists regarding student learning outcomes or academic performance in a flipped versus traditional (lecture-based) classroom (for reviews, see O'Flaherty and Phillips 2015).

The concept of flipped learning was offered by Bergmann and Sams (Bergmann, Sams 2012). They recorded classroom lectures and placed the videos in the Internet for students to watch and revise the learning content easily. This technology provided significant learning results which inspired the authors to use it further before in-class lessons (for example, in the form of online video instructions). This way students could get ready for the lessons watching video materials and could acquire knowledge on a definite topic before the beginning of in-class lessons. Thus, such approach provided more time for active learning in the classroom which allowed to involve students in deeper study of a discipline and discover and correct possible mistakes and problems (Bergmann, Sams 2012). Various scientific sources can give different definitions of the notion of flipped learning. That is why we offered our students to choose one or several definitions of the notion whereas there was one which did not correspond the sense of the notion. It helped to define the most relevant definitions of flipped learning from those offered by several scientists and also to find out that 10% of students who took part in the survey had a wrong idea of flipped learning technologies.

According to the results of the survey different definitions of flipped learning can be ranked:

- Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (FLN 2014) – 61%.
- Flipped learning is a pedagogical approach in which the conventional notion of classroom-based learning is inverted, so that students are introduced to the learning material before class, with classroom time then being used to deepen understanding through discussion with peers and problem-solving activities facilitated by teachers (HE Academy 2015) – 46,8%.
- Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa (Lage et al. 2000) – 35,1%.

Analysis of scientific studies shows that a considerable part of teachers all over the world have already been using flipped learning (Hwang 2015) as:

- Teachers use multimedia technologies to provide students with learning materials which allow them to learn regardless of time and location. Students are taught to search and choose required information and data for in-class lessons, and it is expected that they will be more active and responsible for their study.

- Learning video allows students to watch learning content several times if needed for acquiring deep basic knowledge.
- Digital multimedia learning materials are easy to store, watch, change and transfer.
- In the process of preparation to implementation of flipped learning teachers can check and give all the students access to a curriculum, tasks and requirements for learning results and their assessment, constantly improving pedagogical design of students' activities and learning content.
- When students have sufficient basic knowledge on the learned topic, they get more time for active learning, own questions formulation and discussion, defining practice-oriented problems and their collaborative solution. Under the circumstances teachers are able to give individual consultations which help students to overcome difficulties in study.
- Active involvement and discussion in a classroom can increase the level of collaboration between students and teachers. Active atmosphere might increase students' learning motivation, and thanks to collaboration with co-learners learning effect will grow.
- Additional learning strategies such as project-based learning, inquiry-based learning and problem-based learning can be used for in-class lessons to facilitate development of higher level thinking skills according to Bloom's taxonomy which would be more important for formation of professional and key competences.

We will consider ways of flipped learning technology utilization in the educational process of a university. We will focus our attention on the fact that flipped learning is also a pedagogical concept as z-generation representatives where modern students belong can percept learning material better through visualization of the content (Morze, Smyrnova-Trybulska, Umryk, 2015). That is why it is advisable that a teacher provided students with new material in the format of video lectures or other types of digital learning materials which they could study at home, especially considering that most students have their own mobile smart gadgets. According to statistics, 92% of students use their own digital devices in educational process (Payne 2019). Conducting lessons can be flipped with the help of digital media materials which are placed on a university educational platform. Such educational content is provided with the help of an e-learning course in LMS which allows swapping traditional types of students' in-class activities with the out-of-class ones, that means transformation of in-class (giving new materials) and self-study phases happens.

Flipped learning has 3 phases:

- *Pre-Phase* – which takes place before in-class lesson,

– *F2F (face-to-face)* – active in-class learning,

– *Post-Phase* – following out-of-class learning, reflection.

On the stage of Pre-Phase design, it is advisable to use microlearning technology. Charles Weber formulated a concept of microlearning technology regarding “quick learning in changeable environment” (Weber 2003), which means learning a relatively small amount of learning material and short-term learning, micro-modules. This term is used the most frequently in the sphere of e-learning where it is the easiest to divide learning materials to components. Therewith, every such module has to provide all the aspects of an educational process - brainwork, fulfilment and assessment (reflection) (Zimmerman, Dale 2001). In addition, z-generation students are learning in higher educational institutions now – these are young people born after 1996 for whom it is typical to switch their attention quickly, and who are characterized by online existence, absence of unquestioned authority, etc. (Vember, Buchynska 2018); and flipped learning will help to consider peculiarities of such students.

Let us analyze how the above-mentioned phases of flipped learning are implemented in the process of design and utilization of an e-learning course (Figure 2). Out-of-class activities of Pre-Phase could include classical lectures, individual tasks that contain formative assessment instruments, in particular rubrics, check-lists, assessment forms, K-W-L charts, etc. Active learning (F2F phase) will take place in the classroom during seminars, laboratory and practical sessions using different innovative pedagogical technologies. The end of work, additional tasks and self-study are transferred into Post-Phase (Morze, Varchenko-Trotsenko 2019). The structure of flipped learning using an e-learning course can be presented in Figure 2.

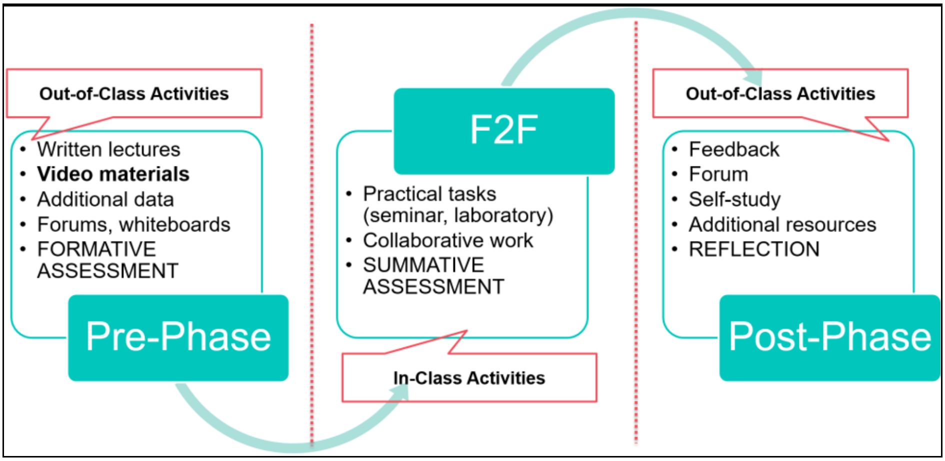

Figure 2. Scheme of materials division in the phases of flipped learning
Source: Own work

The level of acquiring knowledge by students depends on the form of educational work (Figure 3). Therefore, in order to ensure the effectiveness of learning, it is envisaged to apply different forms, methods and technologies, in particular practice through action and training in cooperation. That is why while using flipped learning it is rational to leave the activities in the process of which students acquire less learning material (lecture, reading, video-audio materials, demonstrations) for self-study and to use discussion in groups, practice through action, teaching others etc. during in-class activities.

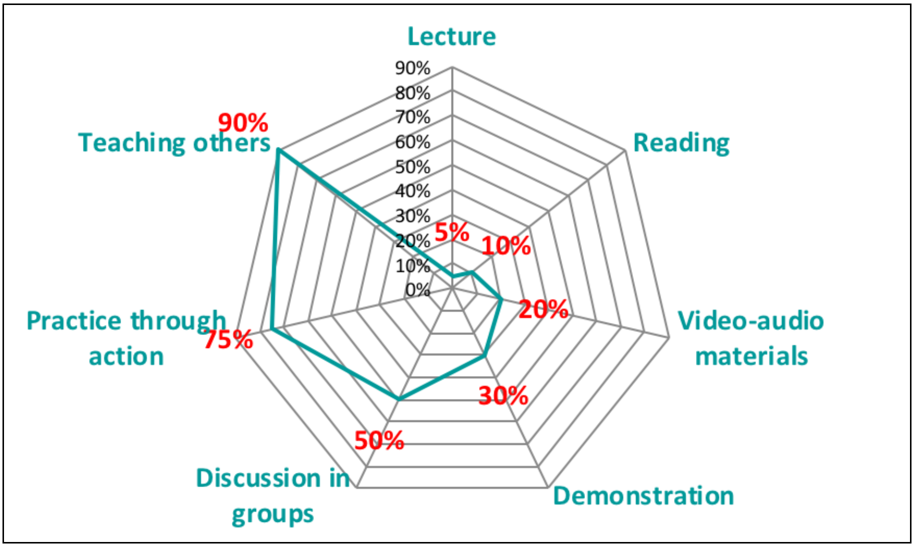

Figure 3. Dependence of the level of students' acquisition of knowledge on the form of educational work.

Source: Morze, 2003

1.2. The model of flipped learning implementation using e-learning course

For implementation of flipped learning technology we designed a model (Figure 4) which takes into account utilization of an e-learning course and peculiarities of learning materials acquisition by different students.

One of the most important stages of the model implementation is identifying **intended learning outcomes** (ILOs) which can be based on Bloom's taxonomy (Bloom, 1994) modified by Anderson and Krathwohl (Anderson, Krathwohl 2001). According to this taxonomy there are six levels of cognitive skills: remembering, understanding, applying, analyzing, evaluating and creating. In flipped learning the tasks students perform out of class belong to remembering and understanding, i.e. to the lowest levels of cognitive learning as materials are used to acquaint students with basic data. During in-class activities higher levels of cognitive thinking skills are formed such as analyzing, evaluating and creating (Hwang et al. 2015). Teacher's role in the classroom is being changed - they become facilitators, use discussions, organize collaborative learning activities, group work, projects, furthers development of students' ability of self-reflection.

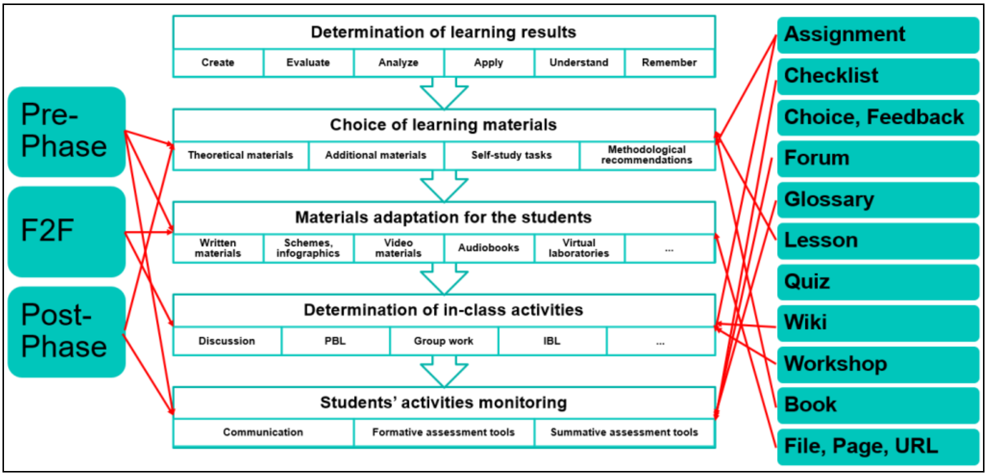

Figure 4. The model of flipped learning implementation using e-learning course

Source: Own work

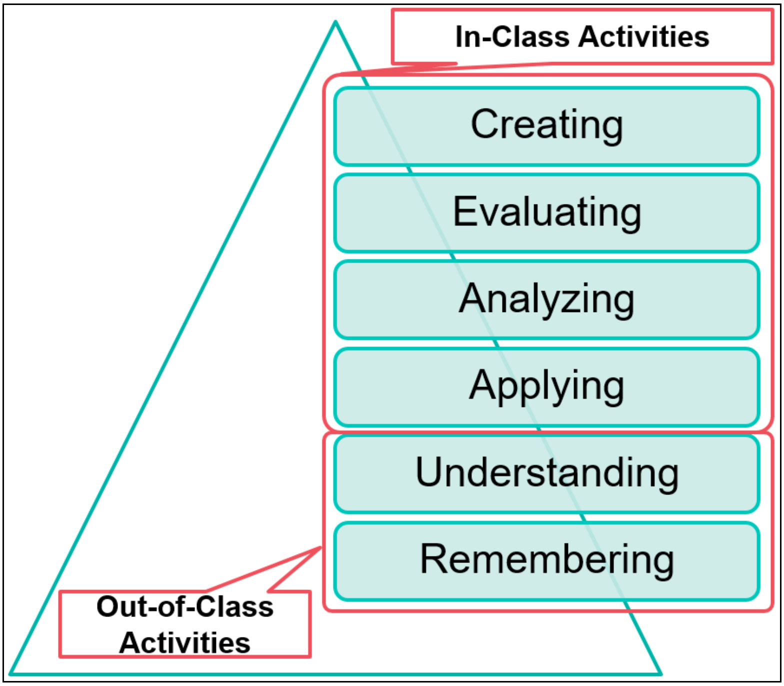

Figure 5. Utilization of flipped learning and Bloom's taxonomy

Source: Own work based on Bloom's taxonomy

On the second stage a teacher prepares learning materials according to intended learning outcomes.

In the process of adaptation of learning materials which will be used in Pre-Phase a teacher should consider that every person prefers different learning styles and methods. Among the classification of learning styles VARK has become the most popular model. In VARK model (Fleming, 1995) which is based on the idea of different type of information perception the following styles are defined:

1. *Visual* - people with a strong visual preference for learning like: different formats, space, graphs, charts, diagrams, maps and plans.
2. *Aural* - people with a strong aural preference for learning like: discussions, stories, guest speakers, chat.
3. *Read/write* - people with a strong read/write preference for learning like: lists, notes and text in all its formats and whether in print or online.
4. *Kinesthetic* - people with a strong kinesthetic preference for learning like: senses, practical exercises, examples, cases, trial and error.

There is an example of VARK model questionnaire available online (http://vark-learn.com). It also contains explanations for every style and recommendations for educational activities optimizing using a correspondent type of information perception and learning style and presented in the way that is appropriate for a respondent. A survey taken by Grinchenko University students has shown that such styles of learning as visual and kinesthetic (Figure 6) are the most widespread, though there are also students with different learning styles even if they presented in minority. That means that teachers should present learning materials in different ways.

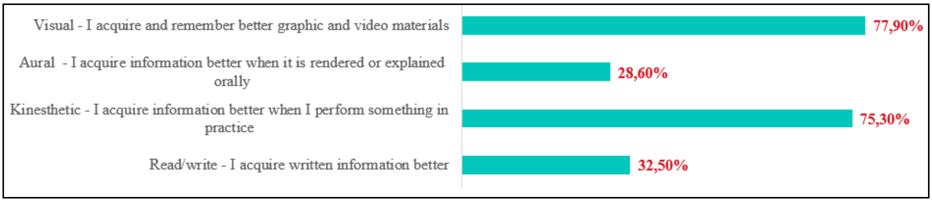

Figure 6. Respondents' answers about learning styles
Source: Own work

Particularly, a clarifying question about the form of presenting materials for acquisition has shown that students prefer such forms as learning videos and presentations (Figure 7):

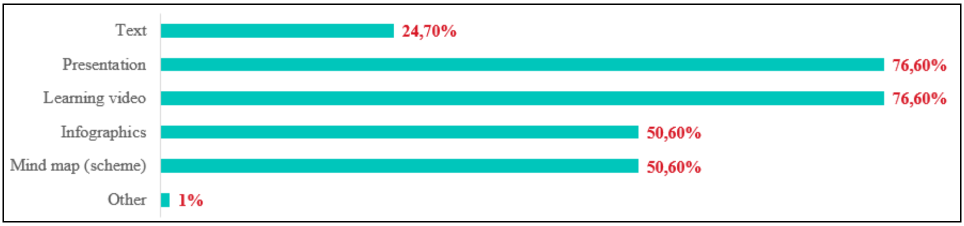

Figure 7. Respondents' answers about Pre-Phase learning materials types
Source: Own work

Therefore, an important aspect for providing Pre-Phase with learning materials is creation of high-quality video materials by teachers. Video materials are an effective instrument as learners receive data through two channels – auditory and visual. Important factors are video content (completed part of learning material), duration (optimal for perception) and type (text data, infographics, speaker recording etc.).

Let us define components of a qualitative video: a duration up to 6-15 minutes, a completed educational idea that corresponds to the learning goals, a natural pace of speech, an interesting content delivery based on an outlined problem with the help of inquiry-based questions formulation. After each video with completed idea students are offered to answer several questions. The questions support all three stages of educational process: they serve as a guideline at the beginning, as a self-check method in the studying process and as a possibility of assessing own results at the end.

At the stage of identifying **in-class students' activities** it is necessary to pay attention to achieving learning objectives aimed at developing higher levels cognitive skills.

Students noted that during in-class lessons they are more interested in such activities as discussions, group and pair work, IBL (Figure 8).

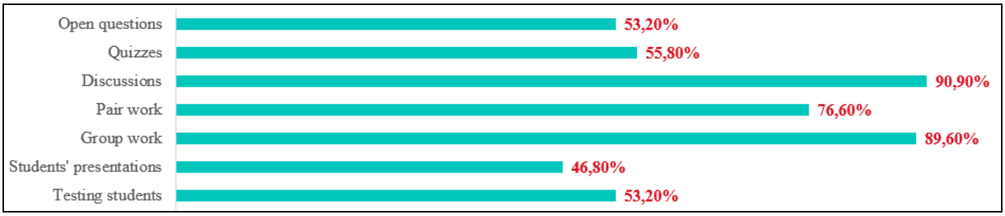

Figure 8. Respondents' answers about learning materials types in the classroom environment
Source: Own work

While choosing instruments for **students' activities monitoring** a teacher defines the ways different communication options will be applied considering both communication among students and with the teacher. It is important to understand formative and summative assessment differences as well.

The peculiarities of formative assessment (Morze, Vember, Varchenko-Trotsenko 2017) include:

- assessment of the learning process itself not limited to the products of educational activities;
- assessment criteria design based on set learning goals;
- students' participation in the assessment process;
- process character of assessment;
- utilization of digital instruments for assessment;
- absence of open comparison of different students' results.

The following methods belong to formative assessment (Figure 9):

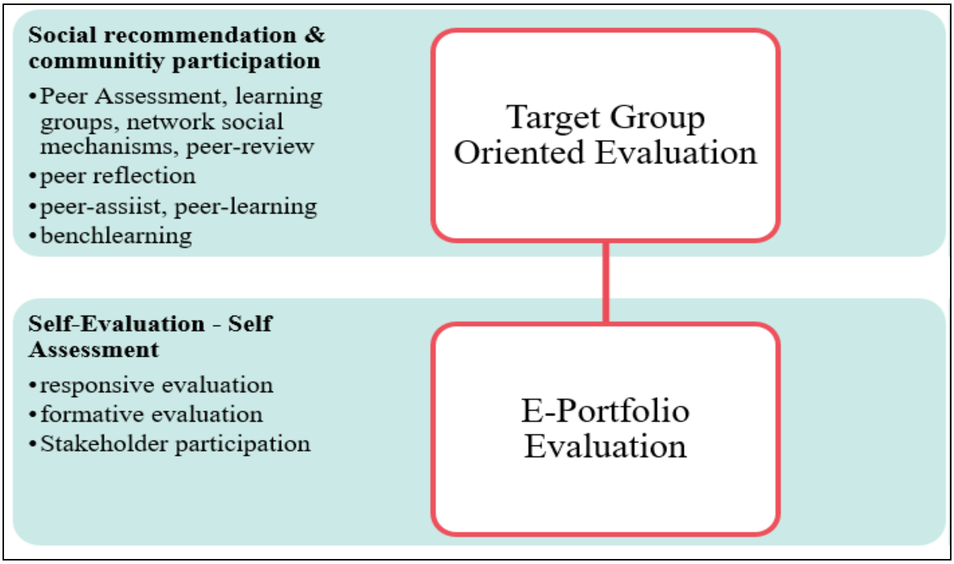

Figure 9. Formative assessment methods
Source: Own work based on Intel

For implementation of summative assessment, a teacher can use traditional or peer assessment.

The peculiarities of peer assessment include:

- strictly defined assessment criteria;
- assessing each other by students;
- receiving a note not only for performed work but also for objectiveness of assessment;
- high efficiency of activities.

Let us specify the stages of implementation of the offered model using the defined resources of an **e-learning course**.

The assignment activity module allows teachers to form tasks, collect assignments, assess them and leave feedback on the assignments. That means this resource can be used for storage and traditional assessment of students' activities results at any stage of learning.

Students can send any digital content (files) such as text documents, spreadsheets, pictures, audio and video files. Moreover, it is possible to allow students to type answers in the body of word-processor in the course. Also, tasks can serve for students as reminders of what they are required to do in the "real world", for example, some creative task which cannot be performed in digital form.

Checklist module allows teachers to create checklists or lists of tasks that have to be done by students. This resource is very useful for formative assessment implementation or tracking students' activities.

Feedback module allows teachers to create own survey to collect students' opinions using different types of questions including multiple choice, yes/no questions or short answers. Feedback can be anonymous if needed; the results can be shown for all participants or for teachers only. Any feedback can be organized on the home page of the website for unregistered users as well.

Forum module allows participants to conduct asynchronous discussions, that is those which take place within long time boundaries. A teacher can use forum both for communication and assessment of students' activities. There are some types of forums to choose from. For example, there is a standard forum where anyone can start a discussion at any time; a forum where one student can create only one discussion; a Q&A forum where students have to send their own message prior to commenting on other students' messages. A teacher can allow attaching files to messages in a forum. Attached files are displayed in the messages of the forum. Messages in a forum can be assessed by teachers or students (independent assessment). Those assessments can be summed up to form a final mark which will be transferred to grader report.

Glossary module allows participants to create and support lists of definitions in the form of a dictionary or collect and arrange resources or information. A teacher can use a glossary both for presenting definitions and for assessment of students' activities.

Lesson module allows teachers to present theoretical materials in a convenient interactive form. Teachers can use a lesson to create single-level web-pages or for learning activities where different ways and options are offered.

Quiz module can be used for conducting traditional assessment.

Wiki module allows participants to add and edit a set of web-pages. Wiki can be joint with access to editing by all the members or individual where everyone has own wiki-page with private access to editing. History of previous versions of every page is stored with the list of changes being done by every member.

Workshop module is designed to collect and analyze students' assignments with collective assessment. Students can present their work in the form of any digital content (files) such as text documents, spreadsheets, presentations and also they can type answers in the input field with the help of word-processor (a link on a blog, a document or wiki-resource, etc.).

Materials are assessed with the help of some criteria defined by a teacher. A process of collective assessment and understanding the form of such assessment can be trained in advance using examples of assignments provided by a teacher with a link on an assessment example. Students are given possibility of assessing one or several assignments performed by co-learners. Materials and reviewers

can be anonymous if required.

Students get two marks for the seminar - the first one is for their own prepared assignments and the second one is for evaluating their colleagues. Both marks are transferred to the grader report.

To present different additional materials there is a possibility of using resources **Book, File, Page, URL**.

2. CREATING THE FLIPPED LEARNING SEQUENCE

Within the framework of the project "Modernization of Pedagogical Higher Education by Innovative Teaching Instruments" (MoPED) of the EU programme Erasmus + KA2 – Development of Higher Education Capacity, the University of Deusto organized and conducted the course "Flipped Learning and Moodle - Assessing Learning Outcomes" which was built on the principles of blended learning: an online course was offered in LMS Moodle, a set of webinars was conducted as well as one-week face-to-face training meetings with the participants of the course.

According to the course assignments we designed flipped lesson sequences with respect to defined requirements.

Let us consider an example of planning a flipped lesson sequence based on Intended Learning Outcomes according to Bloom's taxonomy for the flipped lesson on the topic «Inquiry Based Learning Technique». The following ILOs were formulated (Table 1):

Table 1.

ILOs according to Bloom's taxonomy for a flipped lesson

Bloom's taxonomy	ILO1 – O9
Remembering	ILO1: to define Inquiry Based Learning (IBL) technique, ILO2: to list main phases of Inquiry Learning Cycle, ILO3: to name ICT tools, which can be used to organize IBL
Understanding	ILO4: to explain each phase and sub-phase of Inquiry Learning Cycle
Applying	ILO5: to use Go-Lab portal to find Inquiry Learning Spaces (ILS),
Analyzing	ILO6: to compare different models of Inquiry Learning Cycle and some ILS on Go-Lab portal and their structure
Evaluating	ILO7: to verify if one of the ILS on Go-Lab portal matches the model of Inquiry Learning Cycle
Creating	ILO8: to create ILS as a duplicate of one of the ILS on Go-Lab portal, ILO9: to make some changes to this ILS

Source: Own work

According to identified ILOs a flipped lesson sequence was formulated setting out performance of several types of activities with three phases: preparation phase before the beginning of an in-class lesson – PRE-Phase, an in-class lesson – Face-To-Face (F2F), and completing out-of-class phase - POST-phase.

Activities

1. PRE-Phase

A1 – students individually get acquainted with the materials provided by the teacher (watch the video, read texts) and search more information about IBL on the Internet (ILO1-4).

A2 – task for each student to publish on a forum (type of forum – "Q and A") definition of IBL (ILO1), main phases of Inquiry Learning Cycle (ILO2) and to compare different models of Inquiry Learning Cycle to determine if they have a common and different characteristics (ILO6).

FA1: self-assessment; using another forum - if students have questions, they can write a message on the forum and the teacher or other students will answer it.

A9 – task for students to register on the Graasp environment (graasp.eu).

2. F2F

A3 – discussion with students about IBL, they need to define Inquiry Based Learning (IBL) technique and name ICT tools, which can be used to organize IBL (ILO1,3).

A4 – task for students using Padlet: students in teams (the group of students should be divided into 5 teams) need to write main phases of Inquiry Learning Cycle - one phase per team (ILO2), then in comment to other team's message explain one phase per team (ILO4).

A5 - work in pairs: 1) one participant gives an example of what students will do, and the other determines whether it relates to the IBL technique (ILO 1); 2) each pair of students receives a handout where the student's actions are indicated during each phase of inquiry learning cycle, they need to make up the inquiry learning cycle correctly and define the names of the phases of the cycle (ILO2, 4).

SA1: assessment by teacher (for ILO1-4).

A6 – acquaintance with criteria for searching ILS on Go-Lab portal, task for students to find at least two ILS for primary school (ILO5).

FA2: self-assessment or peer assessment in pair.

SA2: observing the activities of students, assessment by teacher (ILO5).

A7 – task for students (in pairs): 1) to compare two found ILS and their structure: how many phases they contain, what are the names of these phases and discuss in pairs (ILO6); 2) to verify if one of the found ILS matches the model of Inquiry Learning Cycle: if it contains 5 phases, if the phases of the sequence correspond to Inquiry learning cycle and discuss in pairs (ILO7).

FA3: peer assessment in pairs.

A10 – task for students to create ILS as a duplicate of one of the ILS on Go-Lab portal (ILO8).

FA4: self-assessment, the teacher is observing the activities of students.

3. POST-phase

A8 – task for students to create document describing the implementation of task A7 (ILO6-7).

SA3: peer assessment using criteria, given by teacher (ILO6-7).

A11 – task for students to make some changes to ILS created in task A10 ((ILO9).

SA4: students provide their results to the teacher, assessment by teacher (ILO8-9).

The represented consequence can be presented in the form of the scheme (Figure 10):

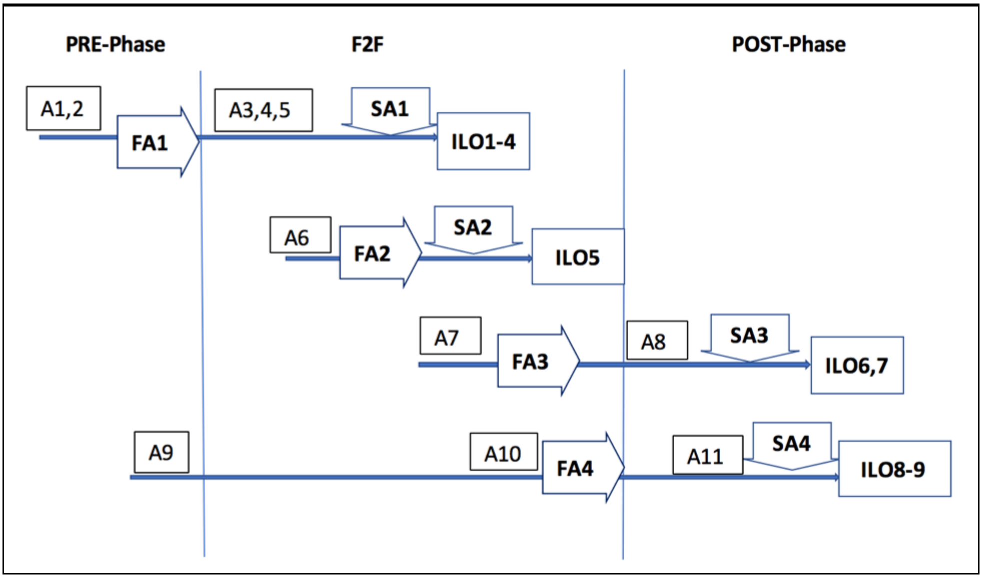

Figure 10. Sequence of flipped lesson activities

Source: Own work

To provide preparative PRE-Phase, give access to necessary materials for students as well as required support the structure of the part of flipped classroom was planned and implemented in Moodle LMS (Figure 11). An example of a page which contains learning videos is presented in Figure 12.

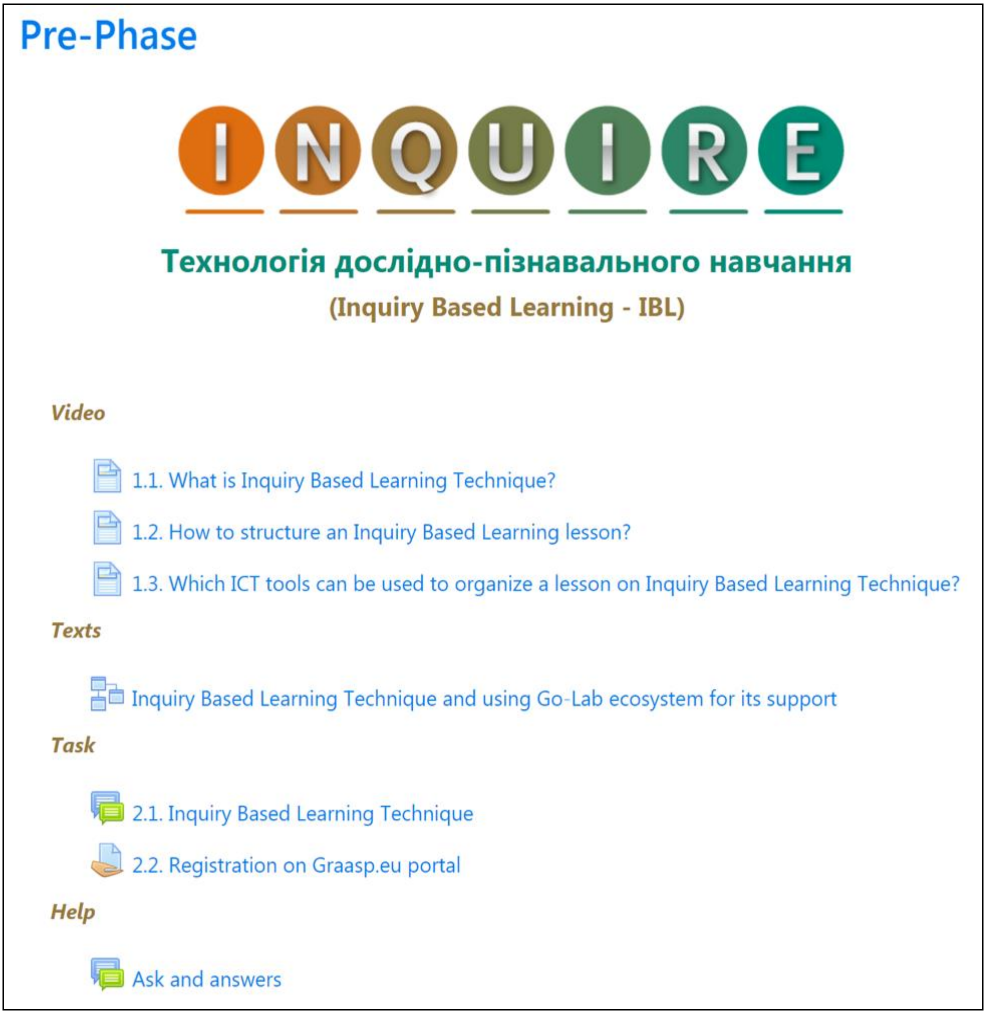

Figure 11. Pre-Phase structuring example for a flipped lesson on LMS Moodle

Source: Own work

Materials can also be given in the form of a text that contains pictures, schemes, infographics and can be divided into units which can be toggled with the help of navigation elements.

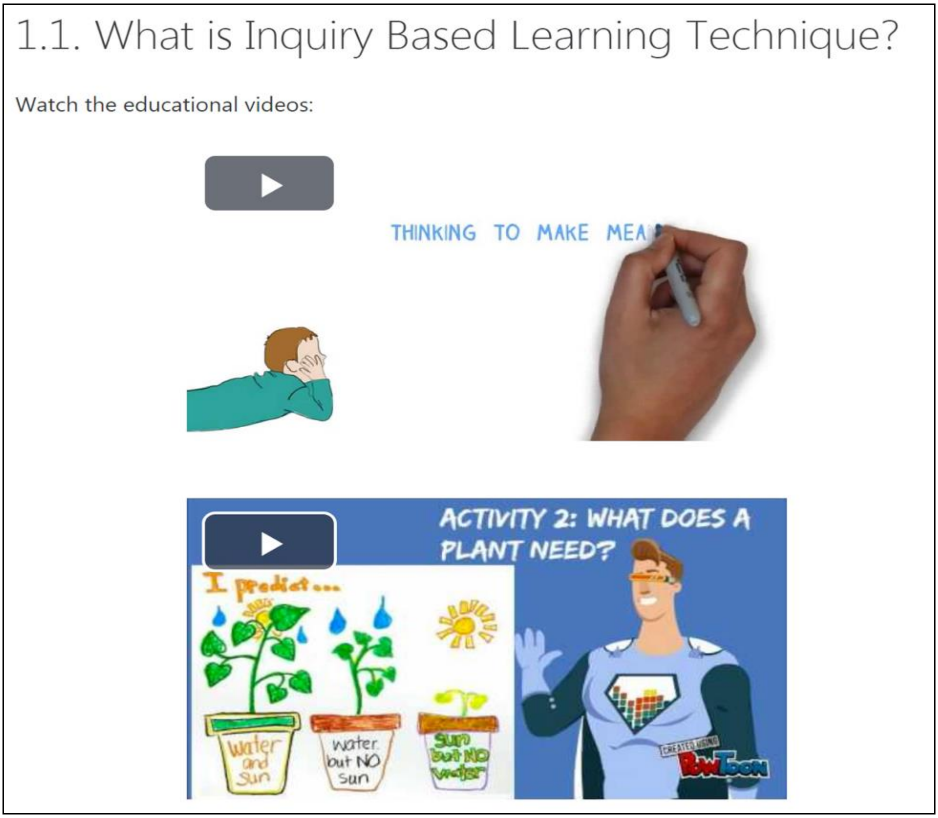

Figure 12. Page with an educational video in Pre-Phase materials

Source: Own work, YouTube

CONCLUSION

A modern higher educational institution requires changes and utilization of innovative pedagogical technologies including digital ones in the educational process. Flipped Learning is a pedagogical approach which increasingly used by the educational community of higher educational institutions. However, a range of requirements must be considered to design an effective flipped learning sequence. All the kinds of activities provided for students to perform have to be planned on the basis of Intended Learning Outcomes taking into consideration Bloom's taxonomy.

It is reasonable to plan the activities which are aimed at lower level Bloom's taxonomy skills formation - Remembering and Understanding - to be done by students before the lesson in Pre-Phase of a flipped lesson. During Face-to-Face Phase students work on problems, advance concepts, and engage in collaborative learning, through this process higher level cognitive skills are being developed.

To finish formation of every planned ILO it is important to provide assessment – both formative assessment in the process of tasks preparation and summative assessment – at the end of all kinds of students' activities sequence that has to lead to the corresponding ILO. Students can finish tasks performance, make peer assessment, accomplish reflection in the Post-Phase.

It is possible to implement the designed flipped learning sequence effectively using an e-learning course, particularly in Moodle LMS. On different stages of flipped learning different resources can be used to provide students with learning materials considering learning styles typical for different students, to organize group work peer-to-peer interaction and peer assessment etc.

Prospects for future research are aimed at implementing and improving the created flipped learning model using e-learning courses.

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IMPROVING STUDENTS' INVOLVEMENT IN TRADITIONAL LECTURES – STUDENTS AS DESIGNERS OF KNOWLEDGE ASSESSMENT TESTS

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Abstract: The authors present two pilot experiments they conducted to find out possibility of enhancement of traditional lectures with simple tools of electronic tests. The pilot research was performed in two different forms, for different courses and different subjects in order to make preliminary qualitative comparisons of the pros and cons of selected approaches. The described approaches were employed for selected lectures of Management and Production Engineering bachelor and master courses at the Faculty of Production Engineering (Warsaw University of Technology). Qualitative findings from the pilot experiments will serve as a basis for the design of next rounds of experiment. The novelty of the experimental approach lays in application of electronic tests as a driver for students' engagement. The approach is based on an assumption that students are themselves designers of tests for specific lectures. Some questions, after verification by a lecturer, are later a part of an official final examination.

Keywords: educational innovation, traditional lecture, electronic tests.

INTRODUCTION

Traditional lectures are still a big portion of engineering and management courses curricula. Due to some administrative and bureaucratic issues they will definitely be still expected for some (maybe long) time. The difficulties related to the change of curricula of specific subjects, modules and courses are hard to overcome. The problems related to traditional lectures relate to their provisional character, mainly one-way communication (teacher-student), students' passive role, substantial need for out-of-class time to understand knowledge, great importance of the lecturer's speaking skills, difficulties with attracting students attention for longer than 15 minutes, etc. Disadvantages may be somehow summarized by the following sentence attributed to Edwin Slosson: "Lecturing is that mysterious process by means of which the contents of the note-book of the professor are transferred through the instrument of the fountain pen to the note-book of the student without passing through the mind of either." (Miller, 1927). It may be noted that the issues related to excelling lectures and elimination of their disadvantages have been part of scientific discourse and practitioners' discussions for a long time and it is still a current issue in the academic community.

1. ADVANTAGES AND DISADVANTAGES OF LECTURES

The definition of a lecture agreed by the authors in this article is the following: "[lectures] represent a conception of education in which teachers who know give knowledge to students who do not and are therefore supposed to have nothing worth contributing" (Bligh, 1998). "Many articles and books on teaching indicate that students' attention declines in the first 10 to 15 minutes of a lecture" (Wilson & Korn, 2007). However, lectures also may have some advantages, e.g. easy scalability of numerous groups. There are also studies proving that some shortcomings of lectures may be eliminated, and lectures may also include active learning principles. Advantages of the lectures (especially in management education – which is the case discussed in this paper) may be summarized in the following way: (Griffin & Cashin, 1989):

– possibility of communicating the intrinsic interest of the subject matter, possibility of clearly communicating a lecturer's own enthusiasm, "which in turn, should logically enhance the audience's interest in learning",
– possibility of covering material not available by other means,
– reaching many learners at one time,
– putting control of the situation clearly in the instructor's hands,
– minimal threat to the student.

On the other hand, disadvantages of the lecture are following (Griffin & Cashin, 1989):

– the lack of students' feedback to the lecturer on learning effectiveness, etc.,
– passive attitude of the student,
– inconsistency of lecture duration and listeners interest spans,

– inability to include individual differences, preferences, characteristics of students,

– dependence on the public speaking skills and abilities of the lecturer.

Improving or even substituting traditional lectures gained interest of many researchers and practitioners including development of massive online open courses, online lectures, video-based lectures (Chen & Wu, 2015), podcasts (Evans, 2008), flipped classrooms (Berret, 2012), blended learning formats (Dalsgaard & Godsk, 2007) and others.

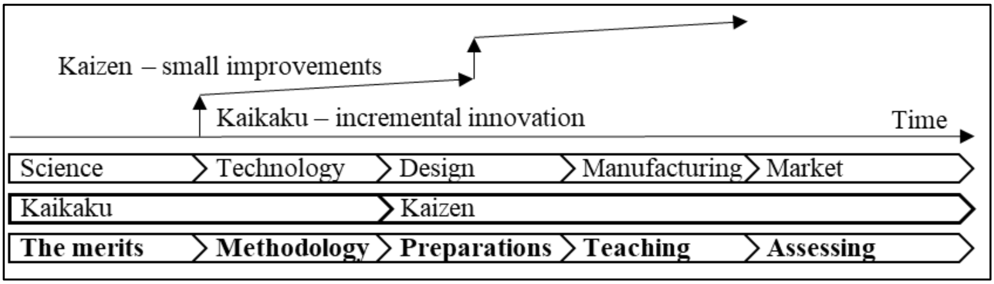

Figure 1. Innovations in education
Source: Own work

Any system, process, and organization need improvement in order to maintain competitiveness. Educational organization does not compete in a purely economic meaning (financial), but they still need to create and maintain strategic advantages. Therefore, as any organization, educational units needs to improve their processes. One may analyse those improvements per analogy to frameworks known from management sciences. One such framework, originated in Japan, considers continuous (ongoing) improvement as a result of everyday small actions (jap. kaizen) and incremental (substantial) changes (innovations) (jap. kaikaku). Figure 1 presents the mentioned analogy and depicts which phases of educational processes are mainly related to kaizen and which to kaikaku.

In this article the authors focused on presentation of their framework focused on traditional lectures and aimed at students' involvement in lectures through a simple means of electronic tests. Students' roles vary and they become not only learners, but also evaluators ~~of~~ themselves. It is approached through assignments of evaluation tests' design. The proposed approach is of an evolutionary nature rather than the revolution and incremental innovation. Therefore, it might be considered rather as improvement and not an innovation in its colloquial meaning of "big change" (Figure 1).

2. EXPERIMENTAL FRAMEWORK SETTINGS

2.1 General characteristics

The limitations of lectures are mostly related to their teacher-centred nature. Therefore, a student-centred approach and constructivism paradigm were adopted in the presented research. The method chosen was a teaching? experiment. Therefore, a phenomenon of students as independent knowledge evaluators, i.e. designers of tests) and its impact on some characteristics of learning outcomes were triggered in a natural students' environment. Then, some observations were performed, and initial conclusions were outlined. Presented research is of a pilot research nature. The goal was to make a pilot test of a construct. The construct assumed that involving students in assignments of the design of knowledge evaluation tests for lectures, is attractive from students' perspective and fosters knowledge assimilation through the need of knowledge structuration by students themselves.

There were two rounds of the pilot experiment performed by the authors. They were performed parallelly in the same semester. Each round was dedicated to a different course. The courses are described in Table 1.

Both experiments, A and B, were performed applying the Kahoot! application (kahoot.it). There are also many other applications easily available on the market, e.g. forms.office.com, quizizz.com, socrative.com. They differ in some features, but basically serve as easy to use applications for evaluation tests (usually short tests) and are available as a freeware. The choice of application is in the authors' opinion based mainly on individual preferences of a lecturer. Therefore, it was not the goal to assess an application itself. The goal was to perform a pilot test of the proposed procedures, to check if they are attractive for selected students, and if they would enable to minimize disadvantages of traditional lectures.

There was also a similar experiment performed, which included three groups of Microeconomics subject. Each group numbered 25 students. It was related to Management and Production Engineering course on Bachelor of Science in Engineering level. It involved only practical classes. Therefore, it is beyond the scope of this article.

The differences between settings included size of a group, subject, level of studies, workload for students (measured in ECTS), individual vs small team assignment, size and number of tests designed by students, scope of possible awards.

Table 1.

Characteristics of pilot experiments

Experiment Students	**Course title**	**Course level**	**Subject title; ECTS and workload; Curriculum**
A 33	Management and Production Engineering	BSc Eng. 6^{th} semester	Production Management, 3 ECTS, stationary course 15 hrs lecture 30 hrs of practical classes (not included in the experiment) usosweb.usos.pw.edu.pl code: 1106-00000-ISP-ZAPRO
B 45	Management and Production Engineering	MSc Eng. 2^{nd} semester	International Industrial Marketing, 5 ECTS, non-stationary course 22 hrs lecture 14 hrs of practical classes (not included in the experiment) usosweb.usos.pw.edu.pl code: 1102-ZP000-MZP-MIMAP

Source: Own work

2.2 Experiment A – basic

The Experiment A framework followed the procedure listed below consisting of four steps. The duration was one semester and it was performed for one group of students.

1) Students worked on tests design individually.
2) Each student was assigned ~~to~~ exactly one lecture topic.
3) Students were asked to design an approximately ten-minute test related to the assigned topic (directly in the Kahoot! application) and share its hyperlink with the lecturer. The deadline was the following lecture. This way ca. 4-5 ten-minute tests were collected for each topic (lecture) and each was required to deliver exactly one test design as a mandatory requirement to get positive final evaluation. The design of test was assessed in binary mode (passed, i.e. delivered / failed, i.e. not delivered).
4) Final exam was designed by a lecturer including 50% of questions (or their modifications) from tests collected from students.

2.3 Experiment B – extended

The Experiment B framework follows the procedure listed below consisting of five steps. The duration was one semester and it was performed for one group of students.

1) Teams consisting of two students were the same as teams formed for practical classes for the same subject.
2) Last ten minutes of each lecture was dedicated to students work. They were asked to design 2-3 questions related to the lecture and write them down. The requirement given to students was to construct questions in a manner suitable for the Kahoot! application. The design of questions was assessed in binary mode (passed, i.e. delivered / failed, i.e. not delivered).
3) Every lecture (excluding the first one) started with a short Kahoot! test prepared by a lecturer. The test consisted of ca. 5-10 questions (ca. 20 seconds per question). The set of questions was chosen, after the lecturer's verification, from questions formed by students. If needed, the questions were modified and supplemented by new proposals of the lecturer.
4) The tests mentioned in p. 3) were evaluated and students who achieved top five results were rewarded. The final exam consisted of two parts: a test part and an open questions part.
   a) Top two results achieved highest grade from the test part of the final exam. However, they had to answer the open questions part of the final exam.
   b) The following three highest results were awarded with extra points for the test part of the final exam.
5) The test part of the final exam was designed by a lecturer, including 50% of questions (or modified questions) collected from students during the semester.

3. RESULTS

The proposed framework was positively verified as the one enabling improvement of traditional lectures without revolutionary changes. It has a four-fold role, i.e.:

- it motivates students for learning,
- it enables to gamify the lecture (only to a limited extent, and just for Experiment B),
- it engages students by adding new activities to a traditional lecture,
- it allows continuous diagnosis of students' knowledge (only for the Experiment B).

The preliminary qualitative analysis of the results and informal discussions with the students showed that the proposed framework might be interesting and encouraging from the students' perspective. Students stressed (in informal discussions) that the proposed approach is interesting for them, because it is "something new and not traditional" and allows better understanding of a knowledge.

The other important issue to be exploited in the proposed approach is the motivational factor. Therefore, approach motivated for learning by rewards in terms of final examination (Experiment B), but also motivated to active participation in tests' design assignment by applying the rule that 50% of questions in final examination are related to those designed by students.

It was impossible to note students' exact behaviours while working on tests' design since they were preparing this assignment as ~~a~~ homework. However, informal interviews showed that students themselves applied a kind of similar framework to this task. First, they analysed the whole lecture and fragmented it into similar pieces of topics. Then they created a similar number of questions per topic. Depending on the lecture, the number of questions and the assigned time to answer varied, but the number and time had viable dominants (Table 2).

Table 2.

Some characteristics of tests in Experiment A

	Min	Max	Average	Median	Dominant
Number of questions	10	17	14	15	15
Time to answer	20	60	24	20	20

Source: Own work

Students vastly preferred more shorter questions (dominant 15 questions of 20 seconds per each) of single choice. It was observed that students structured the tested knowledge properly.

Such quantitative analysis was not prepared for Experiment B, because the assignment was much stricter. It was defined that each team must prepare 2-3 questions (single choice) with 4 answers per question (see section 2.3, paragraph 2) every lecture. However, qualitative observations showed that, before the design of questions students analyzed the lecture's content by asking themselves the following questions: if the lecture could be structured into blocks and then what was the most important issue within each block. Thus, they designed questions that relate to possibly all general issues tackled during the lecture. Students revised and discussed the material, which ~~what~~ consolidated their knowledge. Students who were the best scorers in tests, were also among those who were the most active during lectures.

Exemplary tests are available from the authors (Gladysz and Malenczyk, 2019).

The final results (average final mark) were oscillating around 3.8 for the subject in Experiment A. It was higher than in the previous three semesters (ca. 3.5), when the lecture was performed in a purely traditional way. Scores are given in Polish higher education scale, i.e. 0.0 (not classified), 2.0 (failed), 3.0 (moderate), 3.5 (moderate and half), 4.0 (good), 4.5 (good and half), 5.0 (very good). Such comparison was not possible for the Experiment B. However, the authors observed better understanding of topics by students in both experiments. For Experiment A, it seems that students achieved better scores for questions related to the tests that they designed. This is one shortcoming of the framework in Experiment A. It was not covering the whole lecture, meaning that students significantly deepen their knowledge only for selected topics. That was not the case of Experiment B. However, in this case deepening knowledge was not that much strong as in the case of Experiment A. A very important factor strengthening effectiveness of teaching was that students had to analyse a portion of knowledge (lecture topic), structure it and decide what should be included (i.e. is important) in the test designed by them.

The approach proposed in Experiment B seems to be more attractive and involving from the students' perspective. However, it significantly more time consuming from teacher's perspective. On the one hand it engages students during whole semester and for every lecture, but it is not covering all the topics in such details as the other approach (Experiment A) covers one selected topic per student.

CONCLUSION

The strength of the proposed framework is decrease of some disadvantages of traditional lectures without revolutionary actions. The framework reflects issues expressed in the following way: "I hear and I forget. I see and I remember. I do and I understand" (attributed by many to Confucius) or Xunzi's "Not hearing is not as good as hearing, hearing is not as good as seeing, seeing is not as good as knowing, knowing is not as good as acting; true learning continues until it is put into action" (Hutton, 2016).

Thanks to students' engagement in the design of tests for knowledge evaluation, they practice structuring of knowledge, which facilitates their better understanding. The proposed framework minimizes some disadvantages of a lecture (Table 3) as listed by Griffin and Cashin (2007).

It is still an open question, how to address advantages and disadvantages identified for both approaches. Therefore, the open question is also how to construct one unified and reference framework employing basic features present in both proposals. This feature is engagement of students into design of tests to assess their own knowledge.

Table 3.

Decreased impact of disadvantages of traditional lectures

Disadvantage	Description
The lack of students' feedback to the lecturer on learning effectiveness, etc.	It is possible to get some feedback on learning effectiveness through regular but small tests. This enables flexible reactions of the lecturer and deeper discussion of unclear (poorly scored) topics.
Passive attitude of the student	Students' attitudes are less passive. This is achieved through engagement of students in the process of tests' design and motivational factors (simple gamification in Experiment B).
Inconsistency of lecture duration and listeners' interest spans	Tests may be used as breaks in lectures. This may be an enabler to make lecture duration and listeners' interest spans more consistent.
Inability to include individual differences, preferences, characteristics of students	Lecturers are enabled to identify some individual characteristics of the student. This is possible through assessment of tests designed by individuals and observation of their work on tests' design.
Dependence on the public speaking skills and abilities of the lecturer	The attractiveness and effectiveness of the lecture is not fully dependent on the merits and speaking skills of the lecturer. It is also related to simple gamification through tests and students' engagement.

Source: Own work

The research will be continued using the described frameworks to enable deeper analysis and better understanding of the mechanism. For this purpose, experiments will be repeated for next groups for the same subject, but also for new subjects and new groups. Unfortunately, it is impossible to repeat the experiment for another subject within the same group due to course duration constraints.

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A SYSTEM OF EFFECTIVE TASKS IN BLENDED LEARNING ON THE BASIS OF BLOOM'S TAXONOMY

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Abstract. *The article substantiates the choice of B. Bloom's taxonomy as a psychological and pedagogical basis for the selection and creation of a system of the effective tasks for the formation of methodical and informative competence of the future teacher of primary classes. Focusing on the fact that in the hierarchy of the thought processes, the goal is not evaluation, but synthesis, as a way of creating a new idea, the article describes the step-by-step filling of the "Matrices for the creation of a system of learning tasks" with the appropriate tools, followed by the demonstration of samples in the proposed LMS author's "Methodology for teaching computer science in elementary classes". In the article a reasonably sufficient number of educational tasks to achieve educational goals, proved the effective feedback as a necessary component of blended learning instruction, and also noted the balance between the tasks performed in on-line and off-line modes.*

Keywords: Bloom's taxonomy, Digital Competence, a teacher of primary classes, educational tasks.

INTRODUCTION

The process of reformation of education in Ukraine requires from pedagogical community revising, improvement and updating of both educational programmes and didactic and methodical support of their implementation. Involving the achievements of classic theory, modern pedagogical research is connected with the development of flexible teaching technologies that could assure higher quality of education at any level. The indicators of this quality according to quantitative data are competences, the results of education, will to perform professional duties.

Ukrainian law on education provides clear definitions of ‘results of education’ and ‘competences’. Thus, the former is defined as ‘knowledge, skills, ways of thinking, viewpoints, values, other personal characteristics acquired in the process of education, upbringing and development, that can be identified, arranged, valued, measured and demonstrated by the person after accomplishment of a teaching programme or separate educational components. In its turn, the latter stands for a dynamic combination of knowledge, skills, ways of thinking, viewpoints, values and other personal qualities that define the ability of a person to socialize, conduct professional and/or further educational activity.

In view of the above, one can state that the results of education predict, devise and implement an appropriate methodological system or teachers’ technologies, and competences as personal formations are created due to mastering of the results by the subjects of education.

As a forming element of the pedagogical system is goals of education that interpolate in expected results, teachers’ top priority is given to providing a definite structure and strict description of the results of education. They define the progress of the subjects of education on each stage, the level and ways of representation of the given progress. Expected and real results give the opportunity of generalization and determination of qualification limits for different levels of education. They determine the progress of subjects of education at each stage, the level and ways of representing this progress. Expected and actual results provide an opportunity to summarize and determine the limits of qualifications for different levels of education.

Programmed learning outcomes are focused on creating tools, for example, a set of typical tasks that can be used both to achieve results and their qualitative assessment and measurement (Bakhrushin 2019).

In response to this, the problem of creation of a system of effective tasks becomes scientifically relevant. The fulfilment of them will allow future teachers to form their professional competences on the highest level (in our case digital competence).

Background studies. The issues connected with the formation of methodical and IT competence of a primary school teacher, as ‘a fundamental personal quality, that represents his knowledge and skills in the sphere of information and communication technologies, in computer science studying and organization of educational work at primary school, important attitude to his own professional activity, motivation to self-development and professional growth’ (Sagan 2016), are treated by scientists in different aspects. So, investigating the IT or digital component of this competence, focus on knowledge, skills and mastering in the sphere of ICT technologies and the ability of their usage during professional activity (Sukhovirsky 2005, Ovcharuk 2018, Pietukhova 2009, Tataurov, Shushkina 2011, Smyrnova–Trybulska 2018); point to the methodological aspect of the given phenomenon (Vember, Morze 2013, Kolomiiets 2008, Sagan 2016, Skvortsova, Haran 2017).

In recent years the attention of the scientists is focused on the agreement between educational programmes and European structure of teachers' digital competence (DigCompEdu) that defines the requirements concerning the level of a teacher's competence formation in the digital sphere. The frame of teacher's digital competence DigCompEdu specifies six basic areas in which the investigated competence is expressed: professional involvement, digital means, studying and teaching, evaluation, expanding of pupils' opportunities, assistance in acquiring digital competence. Confirming a certain methodological system, scientists face the problem of development and effective testing of means of forming, checking and controlling of teacher's professional competence level, in particular its digital component.

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Our study is being implemented as part of the course "Methodology of Informatics Education in Primary Schools", the purpose of which is to formulate methodological and informative competence of primary school teachers, as 'a fundamental personal quality, that represents his knowledge and skills in the sphere of information and communication technologies, in computer science studying and organization of educational work at primary school, important attitude to his own professional activity, motivation to self-development and professional growth' (Sagan 2016).

The objectives of the course are the formation of a future teacher of general (instrumental, interpersonal, systemic) and professional (subject-methodological) competences (Tuning, 2009). Comparative analysis of DigCompEdu and the studied entity indicates that digital competence is a component of the teacher's methodological and informational competence. Because in our understanding learning outcomes are formulated in terms of competences, the content component of the system is described as a correlation between learning outcomes and relevant competences.

The problem of creating a system of tasks for the achievement of learning results was reflected in the works of Altshuller, Ball, Getty, Savchenko, Uman; general approaches to the use of competency tasks to ensure the formation of information competence have been investigated Morze, Kuzminskaya, Wember, Barna (2010); Isichko drew up the system of tasks on the basis of mathematical modelling (2013), Degtyareva – system of complex tasks in the process of computer science (2015); Zabolotsky - support system for e-Learning as a means of developing ICT competences (2018) etc.

Despite the different approaches to the creation of task systems, scientists are guided by the fact that the properties of such systems should be relevance, integrity, adaptability, dynamism, accessibility, and ability to model.

We approve of the idea of organization of mixed and combined education that allows extending the variety of educational means and optimizing the feedback between all subjects of educational process. The acquired experience and prospects are represented in works by Tryus (2014), Kukharenko (2015), Rashevska (2010), Smyrnova–Trybulska (2018), Skvortsova, Haran (2017). But in both traditional and mixed models of education the problem of creating a system of tasks that provide qualitative mastering of educational content remains relevant. The analysis of appropriate psychological and pedagogical works led to the use of B. Bloom's taxonomy, which includes three spheres of activity: cognitive, affective (emotional and evaluative) and psychomotor and allows creating an effective educational environment that is favourable for the development of interest in cognitive activity among subjects of education (Bloom 1956). So, the taxonomy formed the basis of the system of educational tasks in research by Vakalyuk (training teachers of computer science) (2013); for psychological and pedagogical substantiation when creating educational projects in computer science in the works of Morze, Dementievskaya (2007) and test design (Kuhar, Sergienko, 2010).

The aim of the article is to define the appropriateness of the use of B. Bloom's taxonomy for creating a system of effective tasks in a mixed course 'Methodology of information technology teaching at primary school'.

1. AN EXPERIMENTAL STUDY OF THE EFFECTIVENESS OF THE SYSTEM OF EDUCATIONAL TASKS IN THE PREPARATION OF PRIMARY SCHOOL TEACHERS

The specificity of the result-oriented models lies in step-by-step procedures of achieving these results which optimize the educational process. Among their properties we distinguish:

- instrumental character (actions and operations that are carried out during the process of education);

- diagnostic essence (the ability to check progress in education);
- realistic nature (the willingness of the target audience, infrastructure availability, suitable conditions for implementation of educational process);
- attractiveness (consideration of needs, motives, prospects of realization of the acquired experience for social and (or) professional growth).

The significance of achieving progress in education is handling knowledge. B. Bloom suggested the system of cognitive actions, 6 levels of intellectual processes: from specific to a general one, from simple to a complicated one. While mastering the actions sequentially, the subject of education is acquiring knowledge. B. Bloom's taxonomy is a system of activity that gives a chance of creating algorithms of composing tasks which include all levels of cognitive actions (Table 1).

Table 1.

The system of cognitive actions

The levels of educational goals	**Cognitive process**	**Results of education**
knowledge	rendering, recognition	Memorizing and rendering of information
comprehension	interpretation, classification, comparison, giving of examples, explanation	Transformation of information into different types, interpretation, prediction of the results of actions
application	carrying out of specific actions	Use of educational material in different conditions (familiar and new), implementation of abstract knowledge in practical situations, evaluation of the correctness of the acquired results
Analysis	differentiation, research organization	The ability to structure the material, distinguishing some elements, principles, connections
Synthesis	creation of ideas, planning	The ability to combine elements aiming at getting a new structure

Evaluation	propositions based on criteria and standards, checking of the accordance to the standard	Propositions concerning the correctness and accuracy of the implemented actions

Source: Own work based on Bloom (1956)

According to the educational goals and B. Bloom's taxonomy, the results are divided into factual (the formation of knowledge about particular objects, their properties and connections), conceptual (the formation of a systemic view of the object due to generalization, theory, models etc), procedural (the ability to transform the objects, change their properties etc), metacognitive (defining of the level of adequacy of factual, conceptual, procedural knowledge application in new conditions). In other words, factual and conceptual results define the level of knowledge assimilation, procedural results regulate the level of formation of appropriate skills, and metacognitive results determine the ability to analyse and choose optimal mode of action.

To achieve the goals and get expected results in education we need a system of tasks, the creation of which is reasonable to agree with a modern version of B. Bloom's taxonomy proposed by his followers (Anderson, Krathwohl 2001). In scientists' opinion, in the hierarchy of mental processes the highest position is occupied not by evaluation, but synthesis as a means of creating new things. Thus, the system of tasks is represented in a form of matrix, the slots of which are built in accordance to the scheme: expected result – appropriate cognitive process (Table 2).

Table 2.

Matrix for creating the system of tasks

knowledge	**Cognitive processes**					
	remember	understand	apply	analyse	estimate	create
Factual	+	+	+	+	+	+
Conceptual	+	+	+	+	+	+
Procedural	+	+	+	+	+	+
Metacognitive	+	+	+	+	+	+
	Thinking of lower level			Thinking of higher level		

Source: Own work based on Anderson, Krathwohl (2001)

We will try to fill in the matrix using an appropriate instrumentation with further demonstration of the patterns in our elaborated LMS 'Methodology of information technology teaching at primary schools'. So, the instrument for creating task on memorizing and rendering is represented by tests, that include questions with one or several possible correct answers to select from the given list (factual and conceptual knowledge); matching tasks (procedural knowledge); open cloze (metacognitive knowledge) etc. In the courses elaborated by the authors of this article in Moodle there are presented tests of all types and levels of complexity (Figure 1).

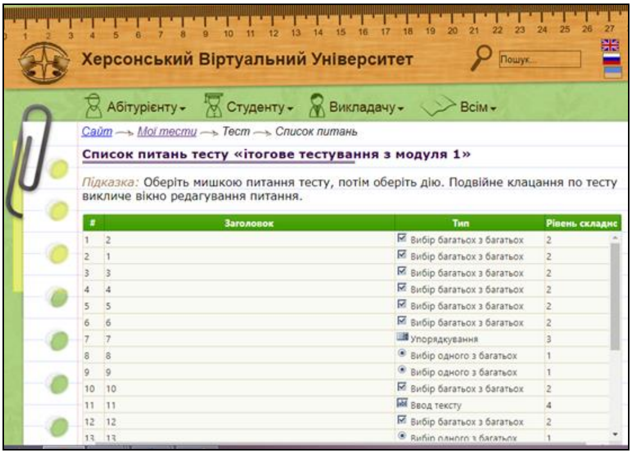


Figure 1. Screenshot of test's fragment

Source: Own work http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(Accessed on: March 04, 2019).

Figure 2. Screenshot of the game 'Data storage'

Source: Based on students' collaborative work https://learningapps.org/display?v=pv8uaxugn19. (Accessed on: March 04, 2019).

Any system of distance education possess the ability to make up tests (Moodle, WebTutor, iSpring Online), as well as the majority of e-learning software (iSpring Suit, Courselab), online-websites (Google Forms, ClassMarker, EasyTestMaker). Memory games can be also created or used as ready-made on LearningApps or Hot Potatoes (Figure 2).

The next level of cognitive processes is the comprehension of facts and notions by the subject of education as a result of organization, comparison, transmission, description, eliciting the main idea. Actually, it means the transformation of the educational material from one form into another. B. Bloom suggested such procedures as transformation, interpretation, extrapolation for solving this problem.

The first one is implemented by means of such tasks as:

1) transformation of information into another form (into another language, from textual into graphical, numeral, combinational etc);

2) transformation of abstract information into specific one;

3) providing of the examples that illustrate and explain the theory.

The samples of such tasks in our course is creating didactic material according to the main themes in course of information technologies for primary school pupils: puzzles, crosswords, games, etc. Thus, future teachers become acquainted not only with possibilities of numerous mobile apps by means of WEB, but also acquire the skill of constructing various tasks for primary school pupils according to certain demands made for such products (sanitary, ergometric) etc.

Interpretation (‘explanation’) is achieved by means of tasks aiming at:

1) pointing out essential features of the subject of research;

2) classifying comparing, finding analogies;

3) searching mistakes.

Extrapolation (‘approximation, estimation’) lies in extension of a particular meaning of the notion or prospects of further problem exploration.

To our mind, the skills to transform information, predict the simplest results of realization of educational material, allow using multiple choice tests and open cloze tests together with traditional methods.

In the conditions of mixed education that we support heuristics has proved its effectiveness. In ‘Philosophical encyclopaedic dictionary” (Shynkaruk, 2002) it is stated that heuristics comes from Greek ‘find, discover’ and is the term used to denote subject area about creative activity, connected with searching of the ways of discovery of new information in propositions, ideas, modes of actions.

In a wide sense, heuristics is:

1) the organization of the productive creative thinking;

2) the science that study heuristic activity, the field science about thinking;

3) a specific method of education.

Heuristics in education is represented by a system of educational questions, the successive answers to which allow a person:

– to make up a monologue (inner or outer) to search or structure information within a particular theme;

– to create a coherent description, arguments to prove or disprove a thesis, conclusions to the theme.

These questions are also called topics. We have elaborated topics (the list of questions) for each theme, so their successive implementation provides a chance for us to give answers to basic theoretical questions, and find confirmation in appropriate works, present our own point of view concerning the prospects of their realization (Figure 3).

Heuristic 1
"Informational literacy"

1. Why do you think there is a problem of 'informational literacy' in the society? What is it connected with?
2. Does this issue belong to the present or the past?
3. Which definitions of this notion can you give (with specific references to certain works)?
4. Which of the definitions correspond to your outlook? Give proofs of your point of view.
5. Which other notions does the notion 'informational literacy' resemble? What is the basis of this similarity?
6. The notion 'informational literacy' contains several components. What is the kind of correlation between them? Is it reasonable to combine them in one notion?
7. Will the essence of the notion 'informational literacy' change if some of its components are excluded?
8. Which actions should be carried out to avoid difference in understanding and comprehension of the given notion?
9. Can you name yourself an informationally literate person?

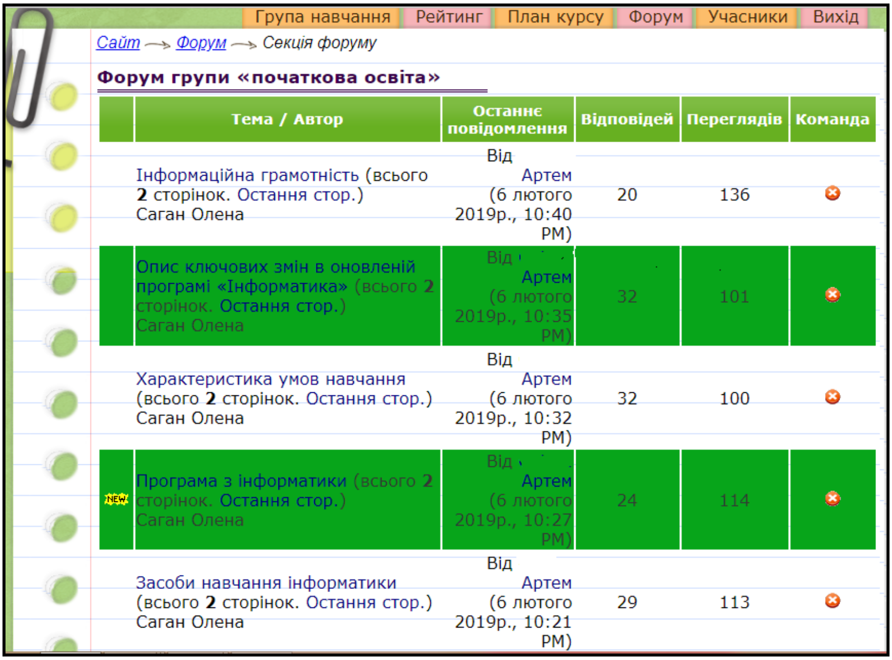
Module 2. Heuristic 3.
"Requirements for control and evaluation primary school pupils' progress"

1. Name the document that regulates the requirements for control and evaluation primary school pupils' progress (with references to certain works).
2. Name the main functions of control of pupils' progress.
3. Name the main objects of control of pupils' progress.
4. Name the main criteria of evaluation of pupils' progress.
5. Characterize the types of control at primary school.
6. In which form the evaluation of pupils' progress in information technologies course is carried out?
7. How is the theme test of pupils' progress in information technologies course implemented?

Figure 3. The examples of 'heuristics' as a sample of tasks to form knowledge on the level of 'understanding'
Source: Own work
http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(accessed on:04 March 2019).

As the class time is not enough for students' mastering of the basic notions, and, moreover, controlling the formation of corresponding knowledge, we suggest practicing heuristics online in LMS with further evaluation of this work by the tutors (Figure 4).

On the next level of 'application' the subject of education demonstrates the ability to solve problems in new conditions, using acquired knowledge, methods, rules by different means. B. Bloom's followers proposed key words as a base for formulation of certain tasks, such as: render, accomplish, estimate, download, present graphically, investigate, prepare, build chart, carry out experiment, explain, etc. If to transform these words into particular types of activity, the tasks can be as follows: prepare a PowerPoint presentation, take part in a role-playing game, create a puzzle, make forum records, and demonstrate the information in the form of figures, schemes, charts.


Група навчання | Рейтинг | План курсу | Форум | Учасники | Вихід

Сайт → Форум → Секція форуму

Форум групи «початкова освіта»

	Тема / Автор	Останнє повідомлення	Відповідей	Переглядів	Команда
	Інформаційна грамотність (всього **2** сторінок. Остання стор.) Саган Олена	Від Артем (6 лютого 2019р., 10:40 PM)	20	136	
	Опис ключових змін в оновленій програмі «Інформатика» (всього **2** сторінок. Остання стор.) Саган Олена	Від Артем (6 лютого 2019р., 10:35 PM)	32	101	
	Характеристика умов навчання (всього **2** сторінок. Остання стор.) Саган Олена	Від Артем (6 лютого 2019р., 10:32 PM)	32	100	
NEW	Програма з інформатики (всього **2** сторінок. Остання стор.) Саган Олена	Від Артем (6 лютого 2019р., 10:27 PM)	24	114	
	Засоби навчання інформатики (всього **2** сторінок. Остання стор.) Саган Олена	Від Артем (6 лютого 2019р., 10:21 PM)	29	113	

Figure 4. A fragment of a website of distance education forum

Source: Own work http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(accessed on:04 March 2019).

Concerning the methods of organization of this activity, it is reasonable to use simulation, game, problem solving, constructing etc. In the conditions of mixed education, the students are offered not only tasks from practical lessons but also those which are fulfilled by means of web-apps. For example, in the process of mastering of main themes in the information technology course for primary school pupils – information, commands and performers, Internet, graphics, text – students are offered certain instruction materials that can be used during the stage of actualization of pupils' knowledge and motivation as well as for training the acquired knowledge among pupils. The key notions in the theme should be coded in the form of puzzles, riddles or represented in a shape of 'a cloud of words' etc., and the results of the work should be downloaded on the virtual platform Padlet (Figure 5).

'Revelation' of the results on such a platform allows students to estimate their own work and comment on it. Except of the formation of methodological competence future teachers master different apps: Tagxedo, Padlet Quiver, Pinterest, «Ребуси українською» (http://rebus1.com/ua) etc.

Tasks on the level of 'analysis' are oriented on the formation of students' skills to divide the material into components in order to observe its clear structure. Analysis as the ability to classify allows presenting information in a form of its constituent:

1) elements (assumptions, facts, hypothesis, conclusions, etc). Mastering of such an analysis type by the subject of education helps to form his skills of mistake identification, differentiation of objects components, distinguishing of common and different features;

2) connections (reason and consequences, assumptions and conclusions, etc) that change into the skill to correlate hypothesis with consequences, reconstruct events and relations, etc.;

3) principles of organization (form, model, material) that implies the skill to structure the activity.

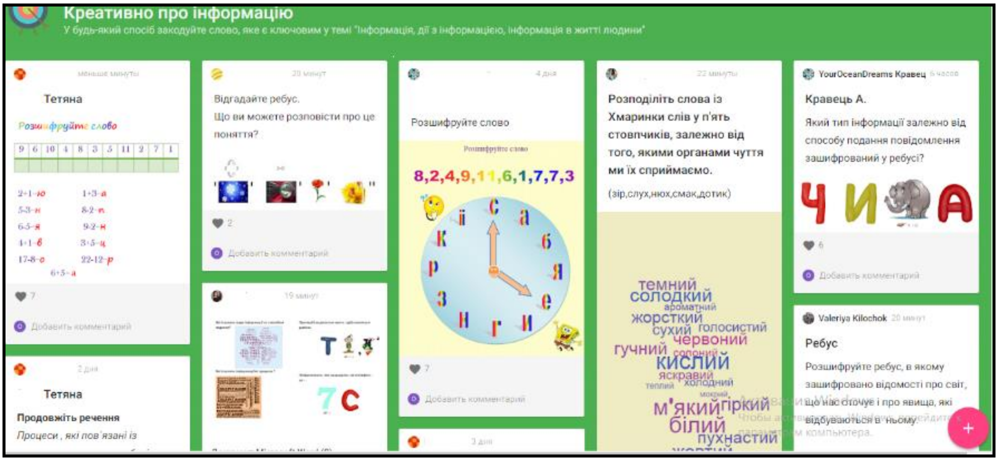


Figure 5. Fragment of the virtual platform 'Creatively about information'
Source: Based on students' collaborative work https://padlet.com/evsagan777/zb3c7hpm09xs. (accessed on: 04 March 2019).

The samples of such tasks in our course are represented by the analysis of schoolteachers' lessons. The program of any methodical discipline involves the formation of students' skills to analyse normative documents, make up a plan and synopsis of the lesson, choose didactic support etc. It is evident that observation and analysis of other teachers' lessons should precede their own practice. In particular, we use information from Youtube and a collection of video-lessons of teachers who participated in Global Teacher Award. To save class time students are provided with some references to lessons that should not be just watched but analysed according to a certain scheme (Figure 6).

In the first stage we use a standard scheme of lesson analysis, and then fix basic pupils' competences that are formed in each stage of this lesson. Taking into account the State Standard of Primary Education that has been in force since September, 2018, and defines 11 key competences as basic that appear in all forms of educational activity, the future teacher must define and differentiate each of them in order to select optimal methods and means of their formation.

The next step is discussion during the practical lesson of such questions as: the presence of methodological and organizing mistakes, successive methods, relevant means, keeping of sanitary norms, correspondence of the given aim and acquired conclusions; planning of our own lesson within discussed theme. Thus, observation, recognition and elementary analysis of the lesson are implemented by the student during his extracurricular activity using particular e-learning resources. Possessing knowledge that enables the student to memorize, understand and apply, with the help of teacher's supervision and working in group he can comprehend the material on a higher level ('analysis – synthesis – evaluation').

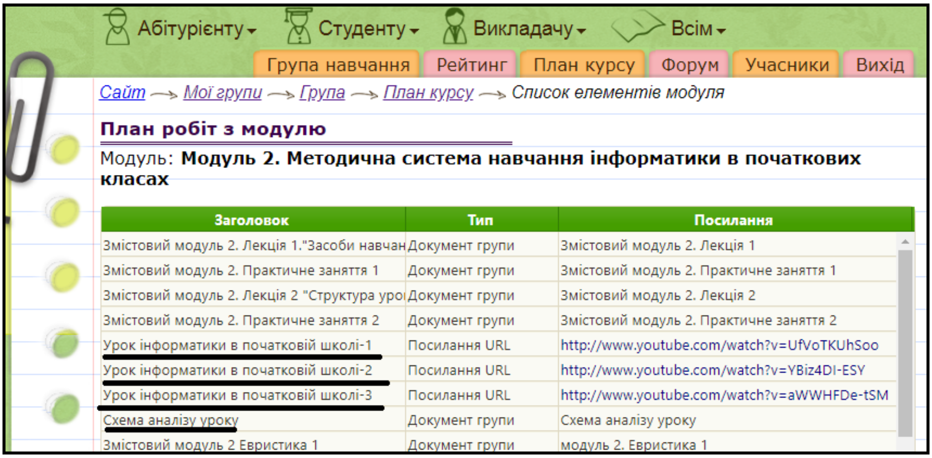


Figure 6. Screenshot of the website with references to information technology lessons at primary school

Source: Own work http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(accessed on: 04 March 2019).

Evaluation helps students to think of the reasons and ways of realization. It is suitable when working in pairs or groups: reviews about each other's work; collective projects. Synthesis as an ability to combine elements to get entity, creating of the new, is formed as the result of such procedures: planning, creation of ideas, practical application. As synthesis belongs to mental operations of the highest level, the tasks have creative constituent that can be presented in the form of composition, essays, report, speech, projects, instructions, nomination of hypothesis and providing its proofs.

If the tasks of lower level are easily graded according to the number of correct answers, the tasks of 'analysis – synthesis' level are distinguished by such criteria as individual fulfilment, creativity, etc. We use the open test form as an instrument in this case limiting the amount of the answers up to 4000 signs (Figure 7). According to our experience it is reasonable to restrict the students while expressing their points of view.

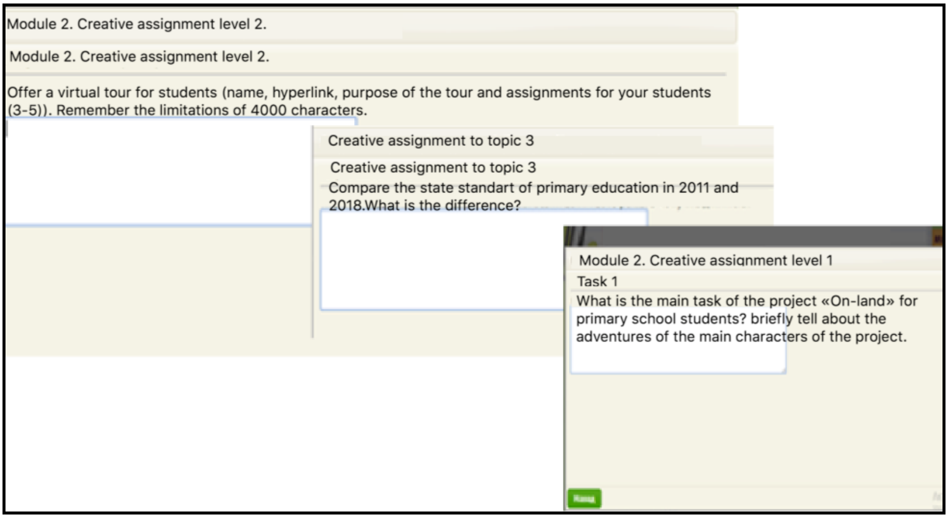


Figure 7. Screenshots of tasks of the 'analysis – synthesis – evaluation' level
Source: Own work http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(accessed on: 04 March 2019).

This method makes it impossible to copy a ready-made answer, causes critical attitude to expression of your thoughts, forces to choose convenient time for creative work implementation, to get personal feedback from the teacher etc. The most interesting variants become the subject of discussion during classes and a motivator for further creativity.

Therefore, while modelling the educational process, we concentrate on full knowledge assimilation in students' mind. This can be achieved as a result of creation of a system of effective tasks in mixed education that is characterized by redundancy and the ability to measure results of education on each stage, on each level of taxonomy. The dynamics of progress in the course and respectively the growth of the level of formation of future primary schoolteachers' professional competences, in particular digital one, are estimated according to such criteria as rating (Figure 8).

Apart from traditional evaluation of students' progress that is defined by the total sum of points for all the activities during the educational module, the teacher takes into consideration the comparative analysis of the ambitions and a real progress of a student during the whole course (the number of site visits and attempts to complete tasks).

Apart from traditional evaluation of students' progress that is defined by the total sum of points for all the activities during the educational module, the teacher takes into consideration the comparative analysis of the ambitions and a real progress of a student during the whole course. For instance, in the process of studying the discipline 'Methodology of information technology teaching at primary school', that consists of 4 modules, the frequency of website attendance in the 4th module has increased by 28% in comparison with the 1st module; the students' attempt to fulfil the task of the highest level ('analysis-evaluation-synthesis') has increased by 35%; the quality of knowledge has faced a 16% increase.

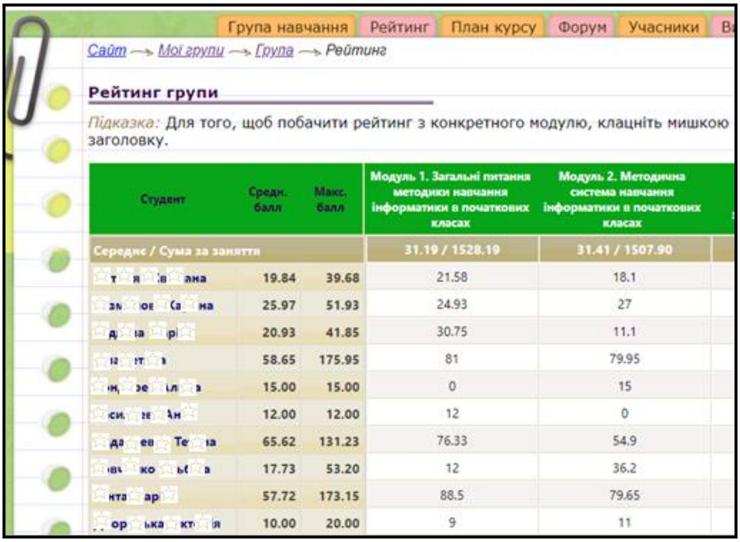


Figure 8. Screenshot of the fragment of rating in academic group
Source: Own work
http://dls.kherson.ua/DLS/MyGroup/GroupDetails.aspx(accessed on:04 March 2019).

The testing of the course using the task system is carried out throughout 2017-2019 with second year students. Since the formation of methodological and informational (and digital as its component) competence continues in the process of further training of students, both at the undergraduate and graduate levels, we will be able to present more stringent results that allow us to evaluate the studied competency using methods of mathematical statistics later. The study used a set of theoretical (analysis and synthesis of Ukrainian and European scientific, pedagogical, methodological sources of the given research and regulatory documents of Ukraine and the EU) and empirical (Fit-bec students) methods, as well as analysis of the results obtained.

2. CONCLUSIONS AND PERSPECTIVES

Acquired results of the implementation of the system of effective tasks in the conditions of mixed education prove the relevance of our scientific and methodological research and allow drawing some conclusions that enable total assimilation of such tasks in terms of the eLearning specificity:

1) The number of tasks should be enough to achieve the educational goals.
2) Educational tasks must reflect a real activity.
3) A necessary condition is providing effective feedback.
4) There should be a balance between online and offline components of tasks.
5) It is reasonable to provide a step-by-step transition from examples to practice.

The involvement of students in educational environment by means of the system of effective tasks had a positive influence on the rate of formation level of motivational component within the investigated competence. This is proved by Feedback results that are arranged by the educational and methodical department at the university, by the growth of the number of students on webinars, online courses, web-schools, that are held by educational portals for primary school teachers.

The perspective of further investigation lies in the improvement of the system of tasks for mixed courses, stating their universal nature for a wide range of disciplines, extension of our experience resulting from the accessibility of elaborate resources.

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EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK "METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4"

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Abstract: *The article focuses on the structure and peculiarities of the content filling of the educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4". The authors describe the methods of its usage in the process of students' self-guided work on the course "Methods of teaching mathematics in primary school". The paper presents the results of the experimental work on introducing this educational and methodological electronic textbook to the process of methodological training of future primary school teachers at the state institution - the K. Ushynsky South Ukrainian National Pedagogical University.*

Keywords: educational and methodological electronic textbook, training of future primary school teachers, course "*Methods of teaching mathematics*", teaching mathematical word problem solving.

INTRODUCTION

Training teachers of the New Ukrainian School is a topical issue in Ukraine's higher pedagogical education. The new State Standard of Primary School (2018), the new standard curricula (2018, 2019) require that the teacher apply modern teaching methods and technologies. Obviously, under such conditions it is the pedagogical university where future teachers should acquire the knowledge, abilities and skills that form the basis of the teacher's methodological competence, in particular in teaching mathematics in grades 1-4.

The goal of methodological training at the pedagogical university is to develop the methodological competence in future teachers. In our study, we interpret primary school teachers' methodological competence as a system-based personal formation, reflected in the ability to organize and conduct the process of teaching mathematics to pupils of grades 1-4 at the level of modern requirements, the ability to solve methodological issues successfully, based on theoretical and practical readiness to teach the subject. (Skvortsova, 2013, 2017).

Primary school teacher's methodological competence in teaching mathematics in primary school is formed as a result of mastering the course "Methods of teaching mathematics". Therefore, it is important to look for ways to improve the effectiveness of teaching this course to future primary school teachers.

1. TRAINING FUTURE PRIMARY SCHOOL TEACHERS IN TEACHING MATHEMATICAL WORD PROBLEM SOLVING

The course "Methods of teaching mathematics" includes lectures, practical / laboratory classes and students' independent (self-guided) work. At the K. Ushynsky South Ukrainian National Pedagogical University (Odesa, Ukraine), his course is structured in 12 content modules, with five modules devoted to methods of teaching mathematical word problem solving to young learners, the content of which is presented through several topics:

Module I "Methods of teaching problem solving in grades 1-2":

Topic 1. General questions of the methodology of teaching problem solving in primary school. Topic 2. Methods of forming the skills of solving simple problems in grade 1. Topic 3. Methods of forming the skills of solving simple problems in grade 2. Topic 4. Methods of introducing the concept of "compound problems". Methods of forming the skills of solving compound problems in grade 2.

Module II "Fractions in the Course of Elementary Mathematics": Topic 1. Methods of forming comprehension of parts of magnitude (fractions). Methods of forming skills of solving problems that contain fractions. Topic 2. Methods of forming comprehension of fractions. Methods of solving problems that contain fractions.

Module III "Teaching methods of problem solving in grades 3-4": Topic 1. Methods of forming skills in solving simple problems in grades 3-4. Topic 2. Methods of forming skills in solving compound problems in grade 3.

Module IV. Typical problems containing constant values are: Topic 1. Methods of forming skills in solving problems for finding the fourth proportional. Topic 2. Methods of forming skills in solving problems on double reduction to one. Topic 3. Methods of forming skills in solving problems on proportional division. Methods of forming skills in solving problems on finding the unknown by two differences.

Module V "Typical problems on processes": Topic 1. Methods of forming skills in solving problems on joint work. Topic 2. Methods of forming skills in solving problems on simultaneous motion in different directions.

The need for such a broad and in-depth consideration of didactics of teaching primary school children is conditioned by the fact that mathematical word problems are the subject of mathematics teaching from the 1st to 4th grades and they form a separate content line of the typical educational programme (2018, 2019) "Mathematical Problems and Research". Our practice shows that for primary school children, solving problems is perhaps the most difficult activity, since solving problems is a heuristic activity that is not algorithmic. Therefore, there is a need for high-quality training of future primary school teachers for teaching pupils solving mathematical word problems, and this, in turn, justifies the search for the means that will satisfy this need.

In the first stage of our research, within the framework of formative experiment, we studied the state of higher pedagogical education in 7 universities of Ukraine which provide training for future primary school teachers. According to normative programmes of the course "Methods of teaching mathematics" approved at these universities, we analysed the number of content modules and hours that were allocated in different universities of Ukraine to train future teachers for further teaching pupils solving problems. We have selected the following programmes for the analysis: K. Ushynsky South Ukrainian National Pedagogical University, Kherson State University, Borys Grinchenko Kyiv University, Ivan Franko National University of Lviv, Mykolaiv V.O. Sukhomlynskyi National University, Lesya Ukrainka Eastern European National University, Vasyl Stefanyk Precarpathian National University, Taras Shevchenko National University "Chernihiv Collegium". The results of the analysis are presented in the table (see Table 1).

Table 1.

The number of hours allocated to the study of the methodological system of teaching mathematical problem solving in pedagogical universities of Ukraine

Name of the higher education institution	Number of modules	Lectures (hours)	Practical (seminars) classes (hours)	Individual work (hours)	Total (hours)

K. Ushynsky South Ukrainian National Pedagogical University	5	26	28	62	112
Kherson State University	3	26	22	42	90
Borys Grinchenko Kyiv University	1	6	6	14	26
Ivan Franko National University of Lviv	1	8	18	24	50
Mykolaiv V.O. Sukhomlynskyi National University	2	10	10	40	60
Lesya Ukrainka Eastern European National University	1	6	8	12	26
Vasyl Stefanyk Precarpathian National University	2	8	12	24	44
National University of "Chernihiv Collegium" Taras Shevchenko	1	8	6	7	21

Source: Own work

As seen from the table, the largest number of content modules and hours allocated to the study of this programme issue is observed at the state institution “K. Ushynsky South Ukrainian National Pedagogical University”. To study all these issues, the developer of the programme (S. Skvortsova) allocated 112 hours of the total number of hours (240 hours). A similar situation is observed at Kherson State University – for studying the methods of teaching mathematical word problem solving 3 modules (90 hours) are allocated.

The analysis of educational programmes also made it possible to see the number of hours allocated for students’ independent (self-guided) work while mastering the methods of teaching problem solving. And in this regard we should mention again the state institution – K. Ushynsky South Ukrainian National Pedagogical University (62 hours from 112 hours) and Kherson State University (42 hours from 90 hours). Thus, it can be argued that these universities have created more favourable conditions for training future primary school teachers in teaching mathematical word problem solving to primary school children. On the other hand, the curricula of most universities in Ukraine allow only 1 or 2 modules and the number of hours varies from 26 to 60 for mastering the methods of teaching problem solving to primary school children.

As a result of the data analysis presented in Table 1, it can be argued that in the pedagogical universities in Ukraine, in most cases very little attention is given to training students in teaching problem solving. Based on the fact that the new version of the State Standard (2018) virtually all the general learning outcomes of the mathematical education field (namely, students examine situations and identify problems that can be solved using mathematical methods; model processes and situations, develop strategies (plans) of actions for solving various problems; critically evaluate data, process and result of solving educational and practical problems; apply experience of mathematical activity in cognizing the outside world) are determined by the components of primary school children's skills of solving plot-based problems, we think it is expedient to allocate more academic time for content modules on methods of teaching solving problems, to update the content of teaching students this issue in accordance with the new normative documents of general primary education. In view of this, the problem of our scientific research is relevant for the practice of training future primary school teachers at Ukrainian higher education institutions.

It is obvious that the shortcomings in the organization of the methodological training of primary school teachers in teaching mathematical word problem solving do not contribute to the acquisition of methodological competence by future teachers. However, when looking for ways to improve the methodological training of prospective primary school teachers we should not limit it only to optimizing the content of the normative programmes of the course "Methods of teaching mathematics" in the sense of increasing the number of hours to study the methods of teaching solving problems. It is important to look for learning aids that create the basis for improving students' preparation for teaching primary school children solving mathematical word problems. Among these aids, scholars have recognized the educational tools which are based on Information Technology (IT).

2. USING INFORMATION TECHNOLOGIES IN TRAINING FUTURE PRIMARY SCHOOL TEACHERS

IT are widely used in modern life, without IT it is impossible to imagine the educational process at the university today, in particular training future primary school teachers. S. Skvortsova and T. Britskan studied the problem of future primary school teachers' readiness for using IT in educational process (Skvortsova, 2019). Scholars studied the problem of training primary school teachers in the use of information technologies (IT) in the process of teaching mathematics, in particular, in the aspect of using a variety of online services for teachers. The author described the peculiarities of the development of modern primary school children's cognitive processes, and, based on this, substantiated the necessity of using IT in mathematics classes. Moreover, the scholar analysed the results of diagnosing the state of teacher's readiness for implementing IT and revealed the necessity of systematic training of teachers for the use of IT.

Therefore, IT is a way to improve the efficiency of training future primary school teachers for teaching mathematical word problem solving; it is possible to use IT not only in the classroom but also in students' extracurricular activities.

The problem of using IT in training future primary school teachers was in focus of work of a number of Ukrainian scholars, namely T. Britskan, M. Haran, V. Imber, V. Kotkova, N. Morse, L. Petukhova, O. Sagan, S. Skvortsova,

O. Spivakovskyi, O. Sukhovirskyi, V. Chichuk et al. Thus, L. Petukhova analysed current approaches to the use of IT in the educational process of universities and proved the effectiveness of the use of the distance learning system "Web-multimedia encyclopaedia 'History of Pedagogy'" in the process of training future primary school teachers (Petukhova, 2007). L. Petukhova, O. Spivakovskyi, V. Kotkova worked out and introduced the course "Information and Communication Technologies in Primary School" into the curriculum of Kherson State University (Spivakovsky, 2011).

O. Sagan, M. Haran and O. Liba emphasize the need to review educational programmes for primary school teachers in the context of forming their methodological and informational competence. The solution of the problem is seen by the authors in transforming the methodological system of informational education through the organization of blended learning, introduction of relevant electronic tools, etc. (Sagan, 2018).

Scientific studies concerning the use of IT when mastering the course "Methods of teaching mathematics" for future primary school teachers by S. Skvortsova and M. Haran, allowed the authors to summarize the requirements for multimedia presentation of a lecture on this course, including requirements to the content of multimedia presentation; to the visual and audio support; to the text; to design; to navigation quality. Compliance with these requirements allowed scholars o create high-quality multimedia presentations of lectures on teaching mathematics that can increase the efficiency of the educational process. This objective was achieved by the authors by enhancing the informative nature of the lecture; stimulating students' motivation to learn; facilitating the perception of educational information through its visualization; stimulating students' attention by means of using animation and colour effects; providing perception, understanding and memorization of information through the simultaneous presentation of information in various modularities (visual and auditory), etc. (Skvortsova, 2018).

The problem of selecting IT tools that could be used in the educational process of universities is widely researched by Ukrainian scholars in collaboration with colleagues from Poland, Slovakia, and Australia (E. Smyrnova-Trybulska, E. Ogrodzka-Mazur, A. Szafrańska-Gajdzica, M. Drlík, M. Cápay, J. Tomanová, P. Švec, N. Morze, R. Makhachashvili, M. Romanyukha, M. Nakazny, L. Sorokina, Tomayess Issa, Theodora Issa). The scholars presented a rating list based on the quality and quantity of the selected IT tools, and offered recommendations for creating a good presentation and didactic video, as well as citing common mistakes made by designers and users (Smyrnova-Trybulska, 2016).

These recommendations can be applied to the use of IT tools in the development of multimedia instruments in any course. Definitely, certain courses have their own specific requirements to consider when elaborating IT-based learning tools.

In the context of the problem of training future primary school teachers for teaching mathematics, S. Skvortsova and M. Haran developed and tested an innovative multimedia methodological complex of the course “Methods of teaching mathematics”. It assumes presence of a constructor of lecture presentations; bank of multimedia materials for practical / laboratory classes (videos of mathematics classes, electronic versions of currently used mathematics textbooks for grades 1-4, normative documents of primary education, educational aids for teachers, etc.); multimedia material bank for students’ independent work (video recordings of classes, electronic versions of currently used mathematics textbooks for grades 1-4, normative documents of primary education, teaching manuals, electronic textbooks and manuals for students, video presentations of lectures, video recordings of comments on certain questions of programmes, references to Internet resources, etc.); test bank (Skvortsova, 2017).

Thus, S. Skvortsova and M. Haran proved the effectiveness of using multimedia tools to increase the efficiency of training future primary school teachers for teaching mathematics.

Among the bank of multimedia materials, the authors distinguish electronic textbooks and students’ course books, but these are only electronic versions of paper counterparts. In our opinion, it is an electronic educational and methodological manual, in which systematic and visualized educational content offering the student an opportunity to study at the appropriate level of difficulty and providing various options for support, educational and final testing, etc., will allow to facilitate students’ independent work. Therefore, the purpose of our study is to develop a content-based and structured electronic educational manual “Methods of teaching pupils of grades 1-4 solving mathematical word problems” for future primary school teachers, and methods of its use by students in the process of independent work.

3. EDUCATIONAL ELECTRONIC TEXTBOOK AS A MEANS OF ORGANIZING STUDENTS’ INDEPENDENT WORK

Electronic Tutorial (Textbook) is an electronic educational publication with a systematic presentation of educational material that is relevant to the educational programme, contains digital objects of various formats and provides interaction (https://mon.gov.ua/ua/news/mon-dlya-gromadskogo-obgovorennya-proekt-nakazu-pro-zatverdzhennya-polozhennya-pro-elektronnij-pidruchnik).

An electronic textbook is not just a pdf file of a regular paper textbook. It is created on the basis of certain software which makes it possible to expand the capabilities of a regular textbook by using all kinds of hyperlinks to multimedia files (audio, video, embedded encyclopaedias, 3D illustrations), cross-links between different sections of the textbook, animation effects (Skvortsova, 2018).

An electronic textbook per se is seen by Iryna Androshchuk and Ihor Androshchuk as pedagogical software that has a convenient hypertext structure and provides educational information, guides the study of a course based on the individual abilities and preferences of students (Androshchuk 2017).

The essential features of an electronic textbook are its interactivity – the possibility of instant feedback, step-by-step control of the action performance, control of the correctness of the action result, an opportunity to receive the necessary dose of assistance (Skvortsova, 2018).

Iryna Androshchuk and Ihor Androshchuk emphasize the interactive nature of an electronic textbook, an opportunity to provide feedback, the availability of navigation and the search engine. Moreover, the level of interactivity can vary from simple movement through links to students' direct involvement in modelling certain processes. Scholars created an electronic textbook "Methods of labour training" for training teachers of labour (Androshchuk, 2017).

The implementation of the interactivity principle in an electronic textbook enables students to become active participants in the educational process, to be engaged in educational and cognitive activities aimed at independent mastering and improving knowledge on a particular topic, educational discipline, to widen their horizons (V. Gushchenko and O. Patsulko 278). Thus, scholars highlight the main advantage of an electronic textbook over the printed one – the possibility of interactive communication between the user and the components of the textbook.

Interactivity is closely related to the opportunity of taking into account the individual characteristics of each student: depending on individual capabilities and needs, students can work at different levels of difficulty – some will stop at basic tasks, while others can do academic research and solve problems of increased complexity, work at levels of analysis, synthesis and evaluation. Thus, an electronic textbook provides means for implementing a differentiated approach, moreover, in two versions – both in terms of the level of difficulty of the tasks and the dose of assistance. With regard to differentiation by the dose of assistance given to a student, this can be either usual clues or highlighting the fragment in which the error was made, redirecting to the theoretical material necessary for the solution, or a link to the ready-made solution with a proposal to perform a similar task (Skvortsova, 2018).

Iryna Androshchuk and Ihor Androshchuk also emphasize the possibility of placing educational material in the electronic textbook according to the levels of complexity. Thus, students themselves choose the volume and complexity of the educational material, the duration of its learning. This is achieved through the creation of a hypertext structure of the manual, the presence of hyperlinks that support the provision of differentiating educational material (Androshchuk, 2017).

Another important benefit of an electronic textbook is provision of students’ feedback. It is through the interactive nature of student interaction, the computer-assisted environment and the availability of an automatic knowledge diagnostic system that students’ feedback is provided. Therefore V. Gushchenko, O. Potsulko offer at the end of their textbook sections to give control questions, exercises, tests, and at the end of the course – final test, which gives an opportunity to obtain information about the level of mastering the educational material (Gushchenko, 2018).

Thus, electronic textbook is aimed at providing an opportunity to take tests (training and control) at intermediate stages and upon completion of the study of the topic; an opportunity to analyze the test results and analyze the material in which the error was made (Skvortsova, 2018).

This will increase the effectiveness of independent study, self-control, improve students’ cognitive activity and motivation, and give teachers an opportunity to analyze and correct the educational process.

The issue of electronic textbook design is raised by Kimberly Anne Sheen and Yan Luximon. The researchers point out that when designing them, authors do not always take into account how students perceive the interface components. For this reason, researchers shift their focus when designing an electronic textbook to the needs of students. They identify the components of a future electronic textbook that are built on students’ perception of coursework and determine the connection with gender differences, experience, and academic background. The researchers conducted a university-wide online questionnaire and received more than 700 responses. The results showed that text, markers, tools, bookmarks, multimedia, translation tools, dictionaries and encyclopaedias should be included in future electronic textbooks and should be tailored to the curriculum (Sheen, 2017).

Studying the didactic aspect of creating electronic textbooks for training future teachers, E. Ivanova and I. Osmolovskaya focused on options for filling the educational environment (a textbook-navigator, a textbook, a set of materials for independent work, etc.), structuring information (as a scenario of the educational process, the designer of the educational process, the integrator of the specified educational process, etc.). The researchers made a list of materials that can be used as a basis for assigning tasks for students to work independently: 1) videos of classes or their fragments with real teachers and students; 2) a set of articles, texts, normative documents, as well as links that will provide deepening and expansion of students’ subject knowledge; 3) Internet website addresses where students can obtain the necessary accurate information about the subject in a form that most closely matches their psychophysiological characteristics (Ivanova, 2016).

Thus, taking into account, on the one hand, the efficiency of using IT for organizing students’ independent work, and on the other hand, the fact that at least half of the total educational load must be allocated to students' independent study, the relevance of creating an effective educational and methodological support for future teachers' independent work based on IT including the creation of electronic textbooks is quite evident.

4. EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK "METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4": STRUCTURE AND CONTENT

Based on the considered requirements for electronic textbooks, we have developed an educational electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" for students, future teachers in the specialty 013 "Primary education".

On the starting page of the "Electronic Textbook" the title "Methods of teaching mathematical word problem solving to pupils of grades 1-4" is given and two sections are offered: "About the programme" and "Study" (Figure 1).

Figure 1. Homepage of the electronic textbook
Source: Own work

Figure 2. Section "About the programme"
Source: Own work

By clicking on the section "About the programme" we find ourselves on the page which provides information about the developers of the electronic textbook, as well as we have an opportunity to download software on our computer, which will help to work with it at a top level of quality (Figure 2).

Clicking on the button "Study", we find ourselves on the page which contains content modules on teaching methods of solving mathematical word problems in the primary school mathematics course (Figure 3).

Figure 3. Section "Study"
Source: Own work

Figure 4. Sections of the content module 1
Source: Own work

Clicking on a specific content module (Figure 4) the student gets access to the topics that make up this module and to the final testing.

For example, the content module 1 "Methods of teaching problem solving in grades 1-2" consists of the following topics:
Topic 1. "General Questions of Methods of Teaching Problem Solving in Grades 1-2".
Topic 2. "Methods of Forming Skills of Solving Simple Problems in Grade 1".
Topic3. "Methods of Forming Skills of Solving Simple Problems in Grade 2".
Topic 4. "Methods of Familiarizing with the Concept of "Compound Problem". Methods of Forming Skills of Solving Compound Problems in Grade 2".
Final testing.
Each topic is explained through the following sections: lecture, practical work (if planned by the programme), tasks for students' independent work (SIW), list of references and training test (Figure 5).

For example, topic 2, "Methods of Forming Skills of Solving Simple Problems in Grade 1", contains the following sections: "Lecture # 2," "Practical Work," "SIW Tasks", "References" and "Training Test".

By clicking on the section "Lecture", students open a list of questions that are discussed at the lecture (Figure 6). So they have an opportunity to pay more attention to the issues that interest them more.

For example, Lecture #2, "*Methods of Forming Skills of Solving Simple Problems in Grade 1".*

Plan of the Lecture

1. The content of teaching the topic according to the new curriculum.

2. Visual aids and didactic material.

3. The order of studying the topic. Analysis of current textbooks.

4. Methods of teaching specific issues of the topic.

✓ *The content and methods of the preparatory stage before introducing the concept of the problem.*

✓ *Methods of introducing the concept of the problem to the first grade schoolchildren.*

✓ *The technique of forming the concept of the problem and the process of solving it.*

✓ *Types of simple problems for grade 1 and methods of working on them.*

✓ *Learning to write a short record of the problem.*

✓ *Notion of the inverse problem.*

Figure 5. Sections to Topic 2, Content Module 1
Source: Own work

Лекція 2.

МЕТОДИКА ФОРМУВАННЯ ВМІНЬ РОЗВ'ЯЗУВАННЯ ПРОСТИХ ЗАДАЧ У 1-му КЛАСІ

План лекції

1. Зміст навчання теми за новою навчальною програмою (2011 рік)
2. Наочні посібники та дидактичний матеріал
3. Порядок вивчення теми. Аналіз чинних підручників
4. Методика навчання окремих питань теми:

✓ Зміст і методика підготовчого етапу до введення поняття про задачу
✓ Методика ознайомлення першокласників з поняттям задачі
✓ Методика формування поняття про задачу та процес її

Figure 6. Plan of lecture #2, Topic 2, Content Module 1
Source: Own work

Moreover, each of the questions offered, through a hyperlink, "unfolds" as a lecture summary containing basic information, examples and additional information "hidden" in the links. In this way, students have an opportunity to choose independently the volume and level of mastering the material that satisfies their cognitive needs (Figure 7).

For example, fragments of the lecture # 2, "Methods of Forming Skills of Solving Simple Problems in Grade 1":

Content and methods of the preparatory stage before introducing the concept of the problem.

In the first stage of mastering the specific content of arithmetic actions, pupils do practical exercises to combine or remove geometric shapes, and then introduce a schematic interpretation of these arithmetic actions using geometric shapes.

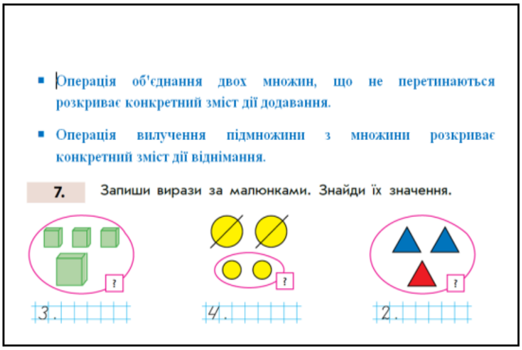


Figure 7. Links – example of the tasks from the textbook
Source: Own work

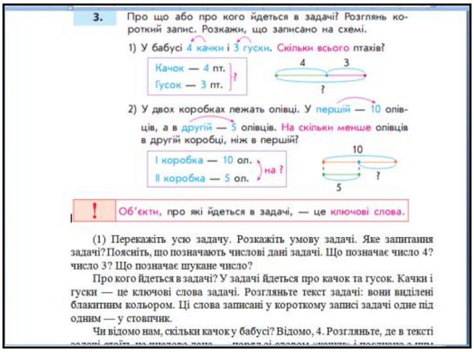


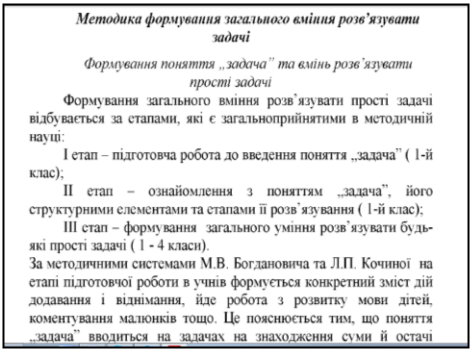
Figure 8. Links – example of the way of working on the task from the textbook
Source: Own work

Teaching writing a short record of the problem

In the next stage, it is advisable to acquaint pupils with a brief record of the problem. This work should be gradual.

First, pupils should analyse the short notes already prepared for the problem, then supplement the short record with numerical data, and, finally, make a short record of the problem themselves (Figure 8).

Figure 9. Section "References"
Source: Own work



Методика формування загального вміння розв'язувати задачі

Формування поняття „задача" та вмінь розв'язувати прості задачі

Формування загального вміння розв'язувати прості задачі відбувається за етапами, які є загальноприйнятими в методичній науці:

І етап – підготовча робота до введення поняття „задача" (1-й клас);

ІІ етап – ознайомлення з поняттям „задача", його структурними елементами та етапами її розв'язування (1-й клас);

ІІІ етап – формування загального уміння розв'язувати будь-які прості задачі (1 - 4 класи).

За методичними системами М.В. Богдановича та Л.П. Кочиної на етапі підготовчої роботи в учнів формується конкретний зміст дій додавання і віднімання, йде робота з розвитку мови дітей, коментування малюнків тощо. Це пояснюється тим, що поняття „задача" вводиться на задачах на знаходження суми й остачі

Figure 10. Fragment of the scanned page from the textbook by L. Koval and S. Skvortsova "Methods of teaching mathematics: theory and practice"
Source: Own work

If after a detailed reading of the lecture content students have any questions, the may turn to the section “References” (Figure 9). Clicking on the References displays a list of manuals and normative documents (if necessary) containing the scanned pages from the primary sources according to the topic of the lecture.

For example, Lecture #2 “Methods of Forming Skills of Solving Simple Problems in Grade 1” (Figure 10).

References

1. Koval L. V. Methods of teaching mathematics: theory and practice: [textbook for students in the specialty 6.010100 “Primary education”, educational and qualification level “bachelor”] / L. V. Koval, S. O. Skvortsova. - [2nd ed., suppl. and ed.] - Kharkiv: Print-Lead, 2011. - 414 p. - P. 342–350.

2. Skvortsova S. O. Methods of teaching mathematics in grade 1: [Methodological manual for teachers of the first grade and students in the specialty 6.010100 “Primary education”, educational and qualification level “bachelor”] / S. O. Skvortsova. - Odesa: Phenix, 2012 - 240 p. - P. 162-199.

3. Bohdanovich M. V. Methods of teaching mathematics in primary school: [textbook] / M. V. Bohdanovich, M. V. Kozak, Ya. A. Korol. - [3rd ed., suppl. and ed.]. – Ternopil: Educational book. – Bogdan, 2006. – 336 p. – P. 260–276.

ЗМІСТОВИЙ МОДУЛЬ 1.

ТЕМА 2. МЕТОДИКА ФОРМУВАННЯ ВМІНЬ РОЗВ'ЯЗУВАННЯ ПРОСТИХ ЗАДАЧ В 1-МУ КЛАСІ

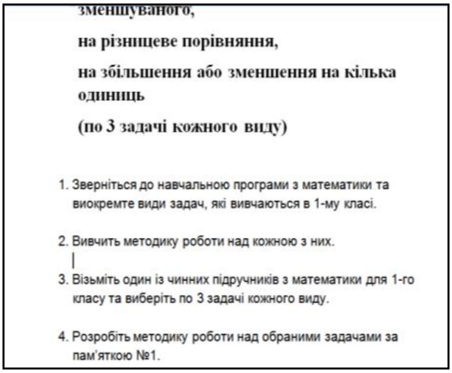
Завдання для самостійної роботи

1. Конспект лекції (0,5 балу)

2. Скласти порівняльну характеристику чинних підручників та чинної програми щодо подання задачного матеріалу (0,5 балу)

3. Скласти методику роботи над задачами: на знаходження суми, на знаходження різниці, на знаходження невідомого доданка, на знаходження невідомого від'ємника, на знаходження невідомого зменшуваного, на різницеве

Figure 11. Section “Tasks for independent work”
Source: Own work



зменшуваного,

на різницеве порівняння,

на збільшення або зменшення на кілька одиниць

(по 3 задачі кожного виду)

1. Зверніться до навчальної програми з математики та виокремте види задач, які вивчаються в 1-му класі.
2. Вивчить методику роботи над кожною з них.
3. Візьміть один із чинних підручників з математики для 1-го класу та виберіть по 3 задачі кожного виду.
4. Розробіть методику роботи над обраними задачами за пам'яткою №1.

Figure 12. Methodological recommendations for students' independent work
Source: Own work

After working on the content of the lecture and literature on the topic, students should move on to the tasks for independent work (Figure 11).

For example, Lecture #2 “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Tasks for independent work

1. Write a lecture summary (0.5 points).

2. Make a comparative description of the current textbooks and the current programme concerning submitting reference material (0.5 points).

3. Work out the methods of work on problems: on finding the sum, on finding the difference, on finding the unknown addend, on finding the unknown minuend, on finding the unknown subtrahend, on comparing the differences, on increasing or decreasing by several units (3 problems of each type) (2 points).

4. Study fragments of the class notes on the given material and prepare one of the notes at your choice (0,5 points).

- *Preparation for studying the problems.*
  - *Methodological guidelines for the class.*
- *Addition and subtraction of 4.*
  - *Methodological guidelines for the class.*
- *Problems on missing numerical data. Problems with extra numerical data.*
  - *Methodological guidelines for the class.*
- *Short problem record.*
  - *Methodological guidelines for the class.*
- *A short record containing three keywords.*
  - *Methodological guidelines for the class.*
- *Inverse problem.*
  - *Methodological guidelines for the class.*
- *Problems on finding the unknown minuend or subtrahend.*
  - *Methodological guidelines for the class.*

Each task for independent work is provided with methodological recommendations and distribution of points, which students can get under the condition of correct completion of the task (Figure 12).

For example, Lecture #2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Tasks for independent work

3. Work out the methods of work on problems: on finding the sum, on finding the difference, on finding the unknown addend, on finding the unknown minuend, on finding the unknown subtrahend, on comparing the differences, on increasing or decreasing by several units (3 problems of each type) (2 points).

Methodological recommendations for performing the task:

1. Refer to the educational programme in mathematics and distinguish the types of problems that are taught in grade 1.

2. Study the methods of work on each of them.

3. Take one of the currently used 1st grade textbooks in mathematics and select 3 tasks for each type.

4. Develop methods of working on the selected problems on the memory note number 1.

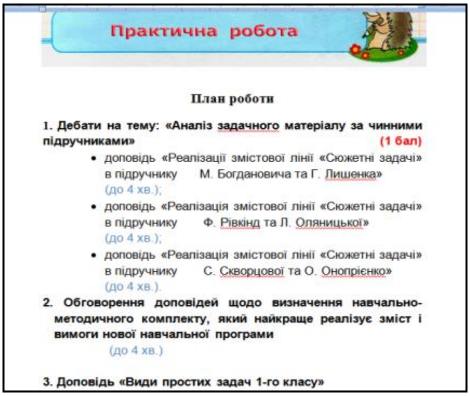


Figure 13. Section "Practical work"
Source: Own work

Figure 14. Section "Training Test"
Source: Own work

For the purpose of effective preparation for practical classes, students may refer to the section "Practical work" and familiarize themselves with the plan of the practical class, prepare reports or fragments of lessons, etc. (Figure 13). Similarly, for each assignment, the number of points that a student can get and the time allocated for the demonstration of solving the assignment are already determined.

For example, topic 2, "Methods of Forming Skills of Solving Simple Problems in Grade 1".

Plan of practical class

1. Debates on the topic: "Analysis of problems according to currently used textbooks" (1 point). Report up to 4 minutes

2. Discussion of reports concerning the definition of an educational set that best realizes the content and requirements of the new educational programme (up to 4 minutes).

3. The report "Types of simple problems of grade 1 (1 min.) (0,5 points).

4. Solving situational tasks (1 point). Demonstrate a fragment of the lesson on working with the problems on:

– finding the sum (6 min.);

– finding the difference (6 min.);

– finding the unknown addend (6 min.);

– finding the unknown minuend (6 min.);

– finding the unknown subtrahend (6 min.);

– comparing the differences (6 min.);

– increasing or decreasing numbers by several units (6 min.).

5. Test on the topic “Methods of Forming Skills of Solving Simple Problems in Grade 1” (15–20 min.).

The training test can be considered a logical continuation of independent work, its purpose is to show the student’s readiness for practical classes and determine the level of mastering the topic (Figure 14).

For example, topic 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”. First, students are provided with a brief instruction on how to correctly complete the test tasks.

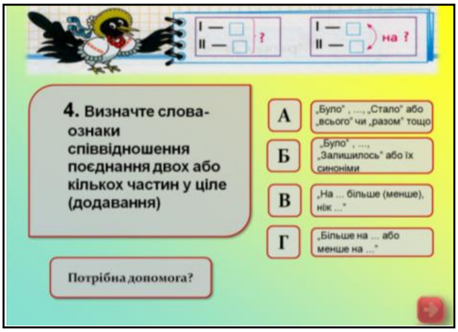


Figure 15. Task of the training test #2 to topic 2 “Methods of Forming Skills of Solving Simple Problems in Grade 1”
Source: Own work

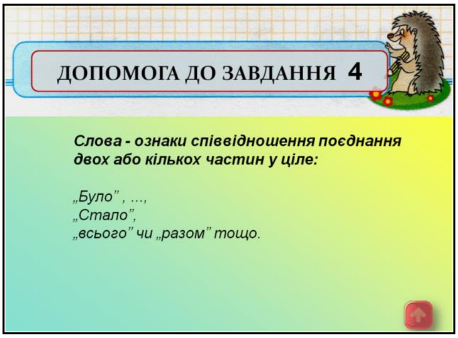


Figure 16. Support for task 4 of the training test 2
Source: Own work

Then, test tasks are introduced to students (Figure 15).

For example, training test # 2 to topic # 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Determine the words-signs for the ratio of combining of two or more parts in the whole (addition):

A) “It was”, ..., “It became” or “in total” or “together”, etc.

B) “It was”, ..., “It remained” or their synonyms.

C) “By ... more (less) than ...”.

D) "More by ... or less by ...".

Do you need any help?

Students are given an opportunity to answer the questions of the test, but if they have any difficulties, they can ask for help in the link, which provides either a lecture fragment or tips, or even the correct answer with appropriate comment (Figure 16).

For example, topic 2, "Methods of Forming Skills of Solving Simple Problems in Grade 1".

Training test #2

Support for the previous task. Words-signs of the ratio of combining two or more parts in a whole "It was", ..., "It became" or "in total" or "together", etc.

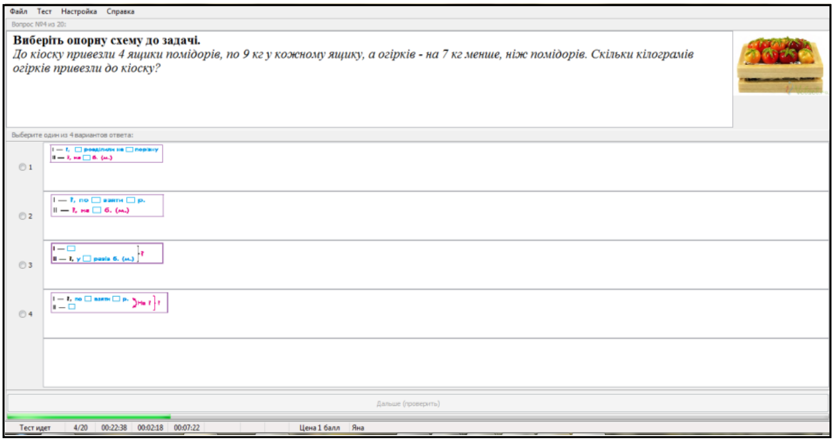


Figure 17. Section "Final testing"
Source: Own work

After mastering all the structural elements of the content module, we invite students to go through final testing, which is a synthesis of tasks from training tests to each topic that are combined by random sampling. The purpose of testing is to determine the indicators of the formation of cognitive component of future primary school teacher's methodological competence in teaching primary school children mathematical word problems solving.

5. USAGE OF EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK “METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4” IN THE PROCESS OF STUDENTS’ INDEPENDENT WORK

The effectiveness of using the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” in the process of students’ independent work in the course “Methods of teaching mathematics” was tested during the pedagogical experiment in 2016-2018.

In order to select experimental and control groups before the beginning of the experiment in the 2016-2017 academic year, we conducted the testing of students of the 3rd year, specialty 013 “Primary Education” of the Faculty of Primary Education of the K. Ushynsky South Ukrainian National Pedagogical University (82 students) and the Pedagogical Faculty of Kherson State University (97 students). Since the course “Methods of teaching mathematics” is based on the knowledge, skills and abilities acquired by students in the course of studying pedagogical disciplines, in particular “Didactics of primary education”, the purpose of testing was to diagnose the level of didactic, psychological and mathematical preparation.

The students – prospective primary school teachers – were offered an initial test that contained 20 closed-ended questions and provided one of four possible answer options. Each correct answer was assessed as one point. The first part of the test was aimed at testing students’ didactic and psychological knowledge. The questions presented in this part of the test involved testing general knowledge and were related to the normative provision of primary education, forms, methods, teaching aids, as well as the psychological patterns of teaching, age and psychological characteristics of primary school children (10 questions in total). The second part of the test was to test students’ knowledge in mathematics. This section included questions about logic, the theory of the multitude, combinatorics, solving equations and inequalities, basics of geometry, as well as the ability to solve basic mathematical problems (10 questions in total).

As a result of processing students’ answers to the test questions, the ratio of the total number of points received by the students during the course of the test tasks performance to the maximum number of points for the test (the coefficient of test performance) was calculated. Summarized results of the initial test, reflecting the level of students’ didactic, psychological and mathematical preparation are presented in Table 2.

Table 2

Average indicators of the level of students' didactic, psychological and mathematical preparation before studying the methods of teaching mathematical problem solving

Name of the higher education institution	Average points	Coefficient of test performance
K. Ushynsky South Ukrainian National Pedagogical University	13,2	0,66
Kherson State University	13,1	0,65

Source: own work

As an experimental group, we chose students of the 3rd year of specialty 013 "Primary Education" of the Faculty of Primary Education of the K. Ushynsky South Ukrainian National Pedagogical University (82 respondents), and as a control group – students of the 3rd year of specialty 013 "Primary education" of the pedagogical faculty of Kherson State University (97 respondents). The students of the experimental group used the educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" in the process of independent work, and for the students of the control group the organization of independent work did not imply the use of this textbook.

The educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" is intended for open access and use in the classroom to provide independent work of students – future primary school teachers during mastering the course "Methods of teaching mathematics", as well as for independent work at home and for practitioners while teaching primary school children solving mathematical word problems.

Therefore, first of all, in the first lesson, students were explained the main purpose of using this guide, its opportunity to contain modern ways of presenting information, interactive means of knowledge control, including those for self-examination.

The electronic textbook itself is located on a separate magnetic medium – a DVD. It has the following parameters: memory capacity is 1.12 GB. System Requirements: Autoplay Menu Designer 3.6, Microsoft Office PowerPoint 2007, Adobe Flash Player.

A copy of the textbook is placed in the electronic archive of the library of the K. Ushynsky South Ukrainian National Pedagogical University (http://dspace.pdpu.edu.ua/).

Each student had an opportunity to use it on-line or download the educational electronic textbook on their computer or on a disk or a flash drive.

Working with the electronic educational manual, the students of the experimental group had an opportunity to get acquainted with the list of content modules on the methods of teaching problem solving; each of them contains several topics, and the students could choose the topic that they wanted to work on.

By going to the relevant topic, namely the lesson plan, the students had an opportunity to study each question in detail by posted hyperlinks from detailed consideration of individual aspects to the description of the methods of work on individual tasks of the textbook. This way, in the volume and content of educational information there is a differentiation according to the level of students' cognitive needs and capabilities.

After mastering the content of the topic, the students took a training test, while performing it, they could use clues, or even look at the correct answer. After mastering all the topics at the end of the module, they took the final test, which is a composition of the training tests' tasks which are composed by random sampling.

After studying the first topic "General questions of the methodology of teaching problem solving" and having passed training tests, the purpose of the survey was to determine the benefits of this textbook to students over the traditional (paper) textbooks in the process of performing tasks independently.

The results of the survey are as follows. 92% of respondents mentioned the opportunity to master the educational material outside the classroom. Even if the students were absent at a lecture or practical class, the electronic textbook could provide them with the information to catch up on missing material, complete self-study assignments, and successfully complete a training test. The positive side is that 78% of the respondents mentioning the usefulness of the electronic educational and methodological textbook do not diminish the role of classroom, communication with teachers and counselling for their own learning.

Another indicator, which was found in 64% of respondents, as a continuation of the first one, is the development of the skills of independent work. That is, the students noted that they were given instructions and methodological recommendations in amount sufficient to master the material on their own. They could not say that about the printed textbook.

The presence of hyperlinks, the ability to quickly move from one part of the textbook to another at any convenient time, was underlined by 89% of respondents. And almost the same number of respondents (84%) confirmed that this method of presenting the educational material contributed to the fast memorization of information.

Working with the electronic educational textbook, the students claimed that it is as adapted to their needs as possible, enables each student, regardless of their level of preparation, to individualize their study, exercise self-control, i.e. to acquire knowledge and skills on the topic at an individual pace, using the required dose while assessing their real capabilities.

Also, one of the advantages of the electronic textbook over the traditional one was seen by the students of the experimental group in its structure which helps students monitor their achievements, it was confirmed by 75% of the respondents.

The purpose of studying the discipline “Methods of teaching mathematics” is the formation of future primary school teachers’ methodological competence, so the final section was aimed at studying the impact of the developed educational and methodological electronic textbook on the level of formation of this personal quality in students.

To determine the level of formation of future teachers’ methodological competence in teaching mathematical word problem solving to young learners, we used the methodology of S. Skvortsova and Ya. Haievets, presented in the monograph (Skvortsova S., 2013). Primary school teachers’ methodological competence in teaching mathematics is understood as a composition of components: normative, variational, special and methodological, technological, design and modelling, control and assessing. Each component contains motivational and value-based, cognitive, activity, reflexive and creative components. Therefore, for diagnosing the level of teacher’s methodological competence in teaching problem solving the following criteria were selected – motivational, content, operational and activity-based (Skvortsova, 2013).

Thus, the effectiveness of using the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” was tested in accordance with the indicators: desire (motivational criterion), knowledge (content criterion) and ability (operational and activity-based criterion) by individual components of primary school teachers’ methodological competence. Differences in indicators’ manifestation (by persistence of desire, completeness and generality of methodological knowledge etc.) are the basis for characterizing the levels of formation of primary school teacher’s methodological competence in teaching problem solving (low, high, sufficient).

The low level proves that students’ activity does not meet the requirements of the teacher’s methodological activity in teaching problem solving to students; the average level of methodological competence allows the teacher to only partially perform professional functions of teaching problem solving according to his available methodological activities; a sufficient level indicates the ability of primary school teachers to teach problem solving and achieve the intended educational goals and students’ development; a high level implies teacher’s creative approach to teaching mathematical word problem solving to students, the ability to create innovative methodological approaches, authorial methods.

After completing the study of modules devoted to the methodology of teaching problems solving, a survey was conducted. The purpose of the questionnaire was to identify the level of formation of methodological competence by the motivational criterion.

The conducted diagnostics testified to the dominance in the control (64%) and experimental (78%) groups of the desire for perfect professional activity in teaching primary school children solving mathematical word problems.

The majority of students demonstrated a well-formed desire to effectively teach mathematical word problem solving to primary school children, working with any educational and methodological set in mathematics recommended by the Ministry of Education and Science of Ukraine (48% in EC and 44% in CG), desire to apply acquired knowledge and skills during real-time mathematics classes according to any educational methodological set (44% in EG and 37% in CG), desire to realize the goals and objectives of the content line “Mathematical word problems” (45% in EG and 28% in CG). There was also fixed a desire to introduce modern teaching technologies to teaching mathematical word problem solving to primary school children (21% in EG and 19% in CG) and to strive for the realization of criteria for assessing pupils’ academic performance in solving mathematical word problems (21% in EG and 20 % in CG).

In order to determine the level of formation of methodological competence by the content, operational and activity-based criterion students went through testing. The final test consisted of two parts: the first part was aimed at the diagnosis of the levels of content criterion formation, and the second part – at the operational criterion of partially-methodological, design and modelling components of methodological competence in teaching pupils solving mathematical word problems.

The summarized results obtained by the levels of methodological competence are clearly presented by means of a diagram (Figure 18).

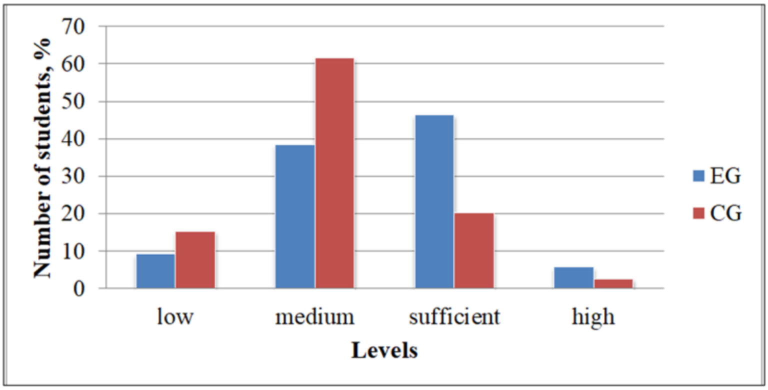


Figure 18. The distribution of students of the experimental and control groups by the level of methodological competence formation
Source: Own work

As evidenced by the results of the pre-final stage of the experiment, 5.8% of the students of the experimental group showed a high level of methodological competence formation, while in the control group the results were 2.7%. 46.4% of EG students and 20.2% of GG students showed a sufficient level. A medium level was diagnosed in 38.5% of EG students and 61.7% of CG students. 9.3% of EG students and 15.4% of CG students remained at a low level.

The analysis of the study results showed significant positive changes in the experimental group. This leads to the conclusion that the use of the developed educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" in the process of mastering the course "Methods of teaching mathematics", which became the basis of experimental learning, offers much better results than traditional training.

CONCLUSION

The efficiency of students' mastering of the course "Methods of teaching mathematical word problem solving to pupils of grades 1-4", in particular modules devoted to the methodology of teaching mathematical word problem solving, is provided by the creation and introduction of the educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grade 1-4" into the educational process.

In the course of independent work, students using this tutorial were able to view a list of content modules on the teaching methodology of solving problems and topics included in each module. By clicking on a specific topic, students move on to the lesson plan, with each issue of the plan also opened through a hyperlink. The content of a specific item in the plan also contains a hyperlink that allows the student in accordance with his or her own cognitive needs to explore the content of the problem more deeply. In addition to the lesson plan, each topic has references to the list of references, and students have an opportunity to study each source by clicking on the hyperlink. By clicking on an assignment for independent work on a particular topic, students are able not only to review the assignment, but also, if necessary, to get recommendations for its completion. If students need more detailed help, they may receive some clues or, even, samples of the completed assignment with a proposal to do the same. Also, on the starting page of the topic, students can review the plan of practical training, go to the training and final tests.

The textbook contains a sufficient number of electronic materials to provide students' independent work: electronic versions of currently valid mathematics textbooks for grades 1-4, regulatory documents, scanned teaching aids for teachers and students, references to online resources, etc.

As a result of the conducted pedagogical experiment, during which the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” was introduced into the process of mastering the discipline “Methods of teaching mathematics”, changes in the level of formation of future teachers’ methodological competence in teaching mathematics were found in the experimental group. It was also found that the students of the experimental group, compared with the control group, have more opportunities to use IT in teaching mathematics to young learners and are more eager to do it. Based on the analysis of the experimental data obtained, we arrive at a conclusion about the effectiveness of the developed electronic textbook for training future primary school teachers in teaching mathematical problem solving to pupils.

The study does not exhaust all aspects of the problem of using IT in training future primary teachers in teaching mathematics in primary school. The prospects for further research may be related to the extension and development of the electronic educational manual to all content modules of the course “Methods of teaching mathematics”.

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WEB-ENHANCED SECONDARY AND ACADEMIC EDUCATION STRUCTURED AROUND EXPECTATIONS AND LEARNING PREFERENCES OF GENERATION Z

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Abstract: *Students from Generation Z prefer online text and image-based learning and they use online resources to learn real-world skills. In order to successfully teach them, educators should shape subject curricula around their behaviours, expectations and needs, which can differ from those of the previous generations. Studies indicate that teachers in Poland understand that web-based education can improve learning outcomes but their instructive, mostly traditional teaching does not result in a synergistic effect. These ideas are supported by secondary school students' attitudes expressed in the survey conducted in the Gdansk region in May and June 2019.*

Keywords: Generation Z, web-enhanced learning, online tools, e-learning, secondary school education

INTRODUCTION

E-learning technologies, i.e. Web 2.0 tools, can help educators deliver engaging programmes with various interactions, resulting in students developing new knowledge and skills. Secondary school lessons and university courses are more likely to arouse interest and stimulate to work, thus leading to satisfactory outcomes, when they are run in environments structured around pedagogical methodologies based on active learning and collaborative achievements (Mokwa-Tarnowska, Roszak, Kołodziejczak 2018, Mokwa-Tarnowska 2018). When the focus in education shifts from an instructivist approach, distribution of information and rote learning, to a constructivist one, which consists in collaborative, problem-based learning and complex skill development, an educational environment will be responsive to challenges posed by a new generation of learners. With capacity for versatile interactions, web-enhanced programmes can better satisfy the needs, expectations, and learning preferences of the cohort, i.e. Generation Z (Beall 2016).

By adding variety to the curriculum through an environment structured around mobile technology and online tools, educators can develop programmes and teach classes that better motivate students and engage them in learning. Such instructional design may contribute to improving the quality of education, both at the secondary level and the academic one. New opportunities can help develop different competencies and literacies.

The paper aims to show how secondary school students that belong to Generation Z perceive web-enhanced education, what Internet technologies they use to support their learning, and how often they use them at school and beyond it. Moreover, it attempts to investigate what expectations they have about an academic learning environment and whether they want it to be traditional or web-enhanced. The presented hypotheses are confirmed by survey results. The findings will be compared against other studies on the use of online tools and mobile technology in Polish secondary schools and higher education institutions.

1. GENERATION Z - LIFESTYLES

There are different terms to describe the generation of people born from the 1990s onwards – post-Millennials, iGeneration, Gen Wii, Net Gen, Homelanders, centennials and Generation Z, the last one being the most widely used (Dimock 2019, Garver 2019, Searle 2019). Researchers agree that a new generation has emerged, and although the oldest and youngest members can differ to a great extent, they share certain attitudes, behaviours and expectations. It is on this basis and not on the span that the classification has been made.

According to Universum, originally a Sweden-based company that now has offices worldwide and which provides market insights to help employers understand career preferences and build strategies, the cohort consists of 100% digital natives. In 2015 its researchers surveyed 49000 members of Generation Z across 47 countries to find out what plans for school and work they had, and what they expected to achieve in their future careers (Dill 2015). Over half the respondents (67%) stated that they were motivated by curiosity when choosing a course of study. The majority considered formal education to be very important and wanted to get a university degree. When it came to career goals, around 50% placed autonomy, leadership opportunities, dedication, creativity and self-employment high on the priority list.

In 2016 the global Randstad and Future Workplace researched ten markets (U.S., UK, Germany, Mexico, Poland, Argentina, India, China, Canada and South

Africa) and surveyed 1965 22-year-olds in full-time employment (Randstad 2016). Their study found that members of the Generation Z cohort would like their employers to use new technologies such as virtual reality, augmented reality and wearables in the workplace (31%, 18% and 30% respectively). Almost 50% of their respondents wanted to have technology-related professions.

Vision Critical and MARU/VCR&C (2019) conducted research on the preferences and attitudes of Millennials and Generation Z. They claim that the new cohort consists of true digital natives who feel very positive about different technologies that surround them, but at the same time they are aware of their limitations. Just under three quarters have a Netflix subscription (71%), and less than half watch cable television. They are keen on Internet of Things, artificial intelligence and job automation (36%, 19% and 20% respectively). More than half the respondents agree that science and technology can solve many of the world's problems. Generation Z rarely reads paper-based information – prefers reading online and using online video to learn real-world skills. It is the first generation who does not have to use other media channels than the Internet, and the first one who is fully immersed in an on-demand world available through interactive technology. Their attention span is largely reduced, even to eight seconds, which may result from them racing from information to information distributed in a visually rich environment. They are also quick online researchers when it comes to information on every aspect of their lives, including finance and health issues. They expect to find treatment possibilities, payment methods and appointment schedules online, in which they and Millennials are alike.

2. GENERATION Z – LEARNING NEEDS AND PREFERENCES

The characteristics mentioned above may have influenced the way employers perceive the needs and learning preferences of the emerging generation. According to the research conducted on Likedin in 2018 (Spar, Dye, Lefkowitz, Pate 2018) Generation Z, unlike Millennials, highly assesses independence and its members are relatively worse at collaboration. This can pose a challenge for companies that value collaborative skills of their employees. One-third of the respondents believe that members of Generation Z will be more difficult to teach numerous soft skills than current workers, particularly communication and collaborative ones. The large proportion of the managers who participated in the survey think that soft skills are more important than technical ones or equally important (92%) and that it is difficult to find them in young candidates (89%). For 90% executives, learning and development of their employees is their priority. The study shows that 68% of the members of Generation Z would like to learn at work, 58% would rather do it at their own pace, and 49% would do it when the need emerged, which is consistent with their likeness of on-demand web services. Moreover, the survey demonstrates that talent developers use online learning solutions to provide content and to evaluate learning outcomes more and more often. Taking the cohort's preferences into consideration, companies are now investing more money into online training, which now equals traditional one.

In order to successfully teach members of the new generation, educators should shape subject curricula around their behaviours (Preville 2018). First of all, learners must be encouraged to collaborate and do assignments from home, because for them learning does not take place in libraries but in online chat rooms. Moreover, teachers need to understand that mobile devices do not dissuade students from learning– they assist them in knowledge development. A shift in the perception of their usability to support university education can be seen in the policy of Ohio State University that in 2018 equipped incoming students with 11000 iPads. The fight against smartphones at school and university will hopefully be over soon, as they can be used as an educational tool whose affordances allow for various interactions beneficial to all involved. Thirdly, universities should adopt personalised learning strategies built on group needs assessment (Zi-Gang 2019), and choose such e-learning environments which do not have detrimental effects on students' academic performance (Feng, Wong, Wong, Hossain 2019) and which best suit their needs (Boczkowska, Bakalarski, Sviatoslav, Leszczynski 2018). The importance of e-learning in professional improvement of emergency nurses. Digital collection of data can speed the analysis of students' experiences and learning needs necessary for improvement. Furthermore, online tools will enable teachers to support their students beyond office hours, which means that consultations will be delivered at a time convenient to both staff and students. Finally, more focus should be placed on peer-generated content. Power and control are more likely to be shared in a university classroom in the years to come.

Just over half of the members of Generation Z (52%) use social media websites to do research, which according to Pareto Law (2019), a UK company specialising in sales recruitment and sales training, shows their willingness for self-control and self-education. The company's study (Pareto Law 2019) reveals that almost the same number of the respondents prefers blended learning methods (51%). However, only 47% of employers currently use this type of teaching, and universities and higher education institutions fare even worse. It is expected that more training will be delivered online in the near future to accommodate the needs of new workers.

3. POLISH TEACHERS' ATTITUDES TOWARDS ICT AND THE USE OF ONLINE TOOLS IN EDUCATION

Secondary school teachers in Poland are trying to adapt to more pragmatic, "tech-savvy" Generation Z by incorporating new technologies into curriculum design. Many classrooms are equipped with interactive whiteboards and virtually all have one computer with Internet access on the teacher's desk, and a TV or a projection screen. Moreover, each school has a computer lab, which is primarily used to teach IT and technology education, and sometimes to support language classes. This presents tremendous opportunities for a shift towards web-enhanced learning. However, many teachers lack knowledge and skills to efficiently use online tools to improve curriculum design, which has been reported in different studies (Polak 2017, Piecuch 2019). Research has shown that there are a number of obstacles to educators being unwilling to use Internet technologies in class:

– insufficient training provided by school authorities and supervising institutions, including governmental ones such as Boards of Education;
– no IT support staff in schools, who can instruct and help less experienced and less skilful teachers;
– teachers' attitudes towards technology-rich educational environments such as reluctance, disapproval, aversion to change, and resentment to new methods;
– longer preparation time for class activities structured around ICT, which means more outside school hours for teachers that increase non-teaching duties;
– lack of money in the school budget for buying mobile devices, computers and apps (Penszko, Zielonka, Trzciński, Cyndecka 2015, 46).

Studies indicate that teachers in Poland understand that school curricula must change to reflect the lifestyles and habits of Generation Z (Plebańska 2017). A majority of teachers treat Internet technology as a relatively good educational tool and they think that they have introduced a sufficient number of web-based activities into the classroom. However, a deeper analysis of their teaching methods has shown that instructive teaching and passive learning dominate in secondary schools and little emphasis is placed on engagement, collaboration as well as different learning styles and needs. Educators teach with ICT but not through ICT.

4. ATTITUDES OF SECONDARY SCHOOL STUDENTS FROM THE GDANSK REGION TOWARDS INTERNET TECHNOLOGIES USED FOR EDUCATIONAL PURPOSES

4.1 Research Design and Implementation

The research presented in this paper targeted secondary school students attending schools in the Gdansk region, both general education and vocational ones, and was conducted in May and June 2019. It consisted in analysing data collected through an online questionnaire that included nine close-ended questions. Some had open response-options and all of them finished with a request to justify the chosen answer. Most of them were Likert scale questions. Information about the survey questionnaire was distributed through social media, chat rooms and in person. As many as 160 questionnaires were analysed, incomplete ones were not taken into consideration.

It can be assumed that the composition of the study group was homogeneous with respect to many factors: age (adolescents aged 15-19), intellectual capacity (students preparing for secondary school leaving examinations), interest in learning (on successful completion all can enrol on a university course) and frequent use of Internet technologies. It can be expected that most of the respondents will enrol in one of Polish higher education institutions if they choose to continue formal education, because, as statistical data show, only a limited number of school leavers decide to study abroad and are accepted to a foreign university.

4.2 Research Questions

The qualitative and quantitative research into the attitudes to Internet–based education and learning preferences of young people in Poland of which part is presented in this paper was initiated five years ago. The previous stages consisted in analysing the nature of web-enhanced language classes offered by Gdansk University of Technology and their impact on an increase in students' hard and soft skills, as well as the attitudes of university staff and students towards online tools to support academic education and their competencies to teach and learn in an e-learning environment. The most resent stage focuses on secondary school attendants and their approach to online learning in and outside the classroom. Secondary school students' opinions also reveal their expectations about the learning environment that they would like to encounter at the academic level. Moreover, they will help uncover some trends to be further tested in the next research stages. The research questions targeted in this phase were as follows:

- What are the secondary school students' attitudes to using online tools and mobile technology to support learning at school and at university?
- What are their learning preferences and how do they relate to technologies pervasive in their lives?
- What are their basic expectations about the nature of an academic learning environment?

4.3 Findings and Discussion

A majority of the secondary school students who participated in the survey want to continue formal education and enrol to university (81.3%), only 5.6% are interested in finding a job, and 13.1% have not decided yet. Half of them are in year 2, 12.5% in year 1, and the same number in year 3, and 25% have just finished school. All of them use different online technologies in everyday life, website creation tools being the least popular (13.5%) and sharing tools have been used only by 16.5% (Figure 1). It is, however, surprising that only 25.6% of the respondents ticked the communication tools box, which may mean that they did not understand the label, because it is unlikely that students who live in a region with easy Internet access do not use such technology – the results of different studies presented in the literature show that only 3.5% of young people aged 11-17 in Poland have never used a mobile phone with Internet connection, and 82.5% use it at least once a day (Pyżalski, Zdrodowska, Tomczyk, Abramczuk 2019, 19-20).

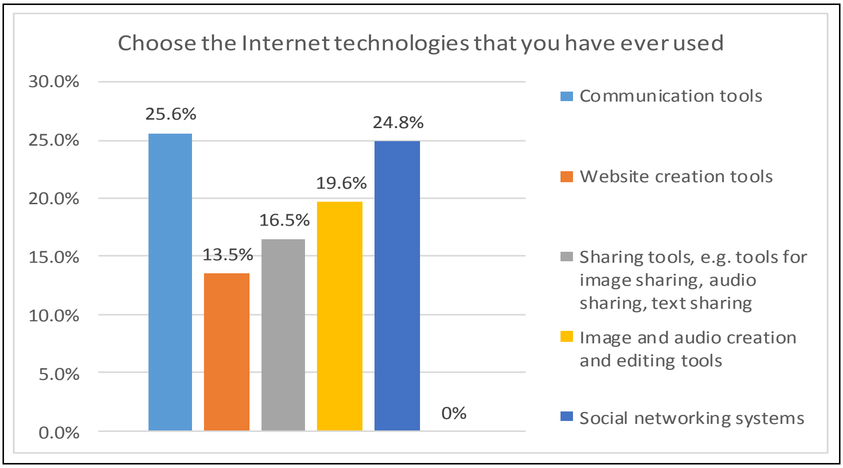

Figure 1. Familiarity with Internet Technologies
Source: Own work

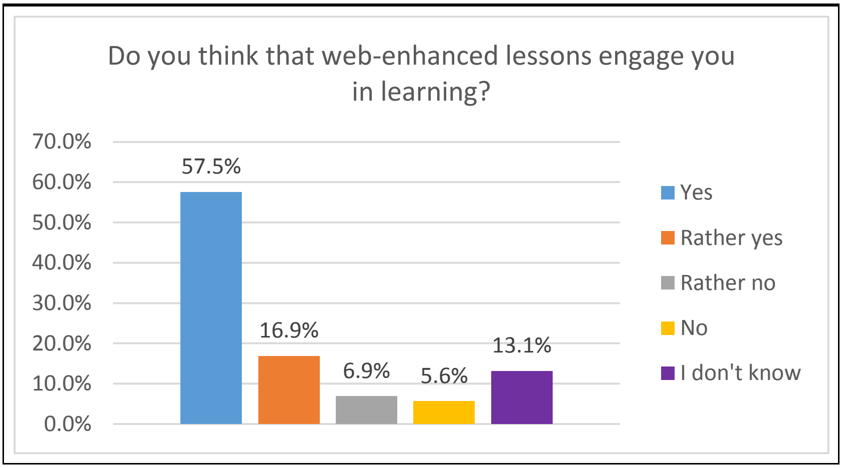

Figure 2. Impact of the Internet on Engagement
Source: Own work

Almost three quarters of the respondents (74.4%) think that web-enhanced lessons are an engaging way of learning, and only 5.6% are of the opposite opinion (Figure 2). This is consistent with other recent studies that have revealed that students often use the Internet to search for information they need for their school activities (Pyżalski, Zdrodowska, Tomczyk, Abramczuk 2019, 45-46).

According to the secondary school students who participated in the survey, teachers rarely support their classes with online materials or do it only from time to time (29.4% and 26.3% respectively) (Figure 3). The only types which were mentioned were quizzes, particularly Kahoots.

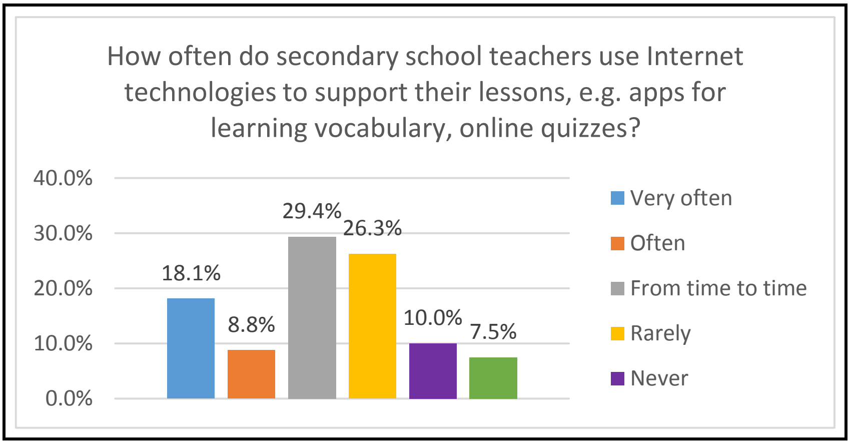

Figure 3. Frequency of Internet Technology Use at Secondary School Level
Source: Own work

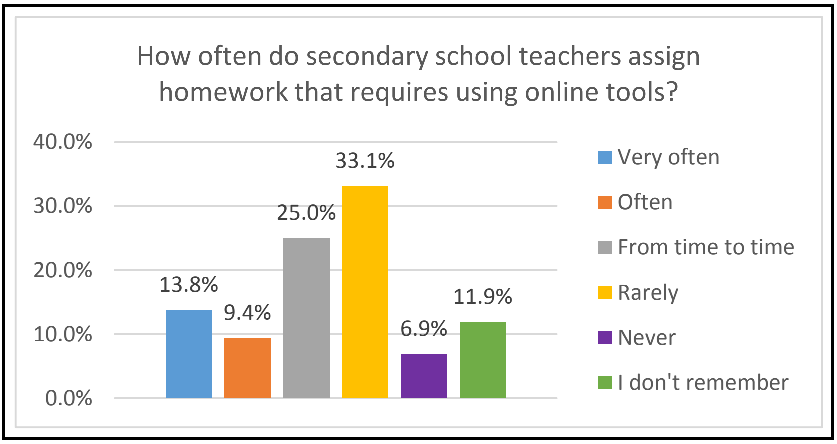

Figure 4. Frequency of Online Tools-Supported Homework
Source: Own work

Similar responses can be seen in the case of the question about the use of online tools to support homework (Figure 4). Only a small percentage of the students stated that their teachers frequently required them to use Internet technology to do homework. More than 30% rarely were asked to do so and 11.9% did not remember if they had been assigned such tasks.

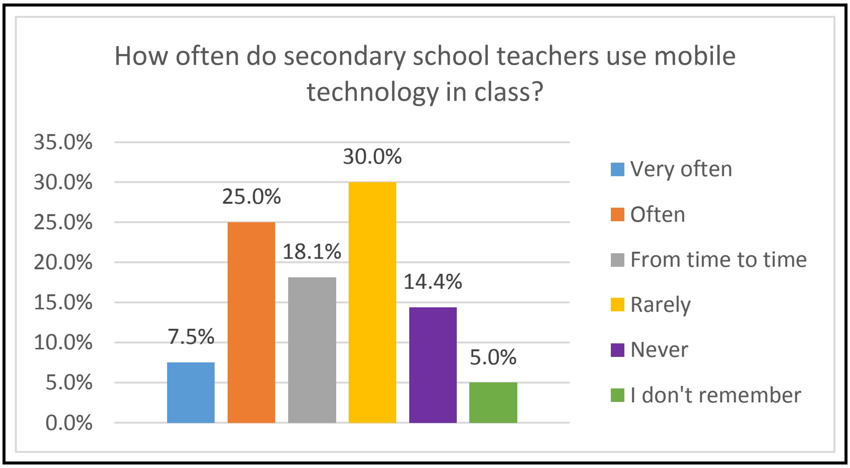

Figure 5. Frequency of Mobile Technology Use in Class
Source: Own work

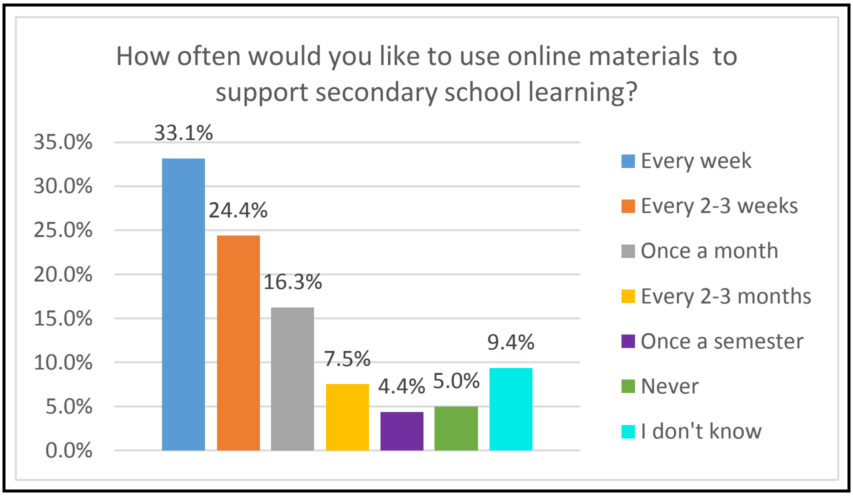

Figure 6. Online Materials – Frequency of Use Preferences
Source: Own work

When it comes to using mobile devices in class, altogether just over 30% of the respondents often had lessons enhanced by such technology (Figure 5). The same number of students rarely needed it and more than 10% had never been asked or required to support their learning with mobile devices. Recent findings presented in the literature have shown that Polish secondary school teachers are rather reluctant to allow their students to use smartphones in class. According to Pyżalski, Zdrodowska, Tomczyk, Abramczuk (2019, 50) as many as 27% of students reveal that Polish teachers want them to have their mobiles switched off during lessons, and 25% report that their mobiles have been confiscated by their teachers. Plebańska's research (2017, 20) shows that only 29% of secondary school teachers in Poland allow using smartphones in class, and only 12% sometimes teaches with tablets.

The members of Generation Z who completed the questionnaire would like to frequently use online learning materials (Figure 6), which is congruous with the understanding of the preferences of the cohort described above. The most popular answers that they selected were 'every week' and 'every 2-3 weeks' (33.1% and 24.4%). Only 5% stated that they did not want to learn from Internet-based resources or activities.

More than 70% of the respondents showed interest in web-enhanced academic education (*yes* and *rather yes* answers) (Figure 7). A minority (4.4%) would not like to use either collaborative tools, communication tools or learning platforms if they become university students.

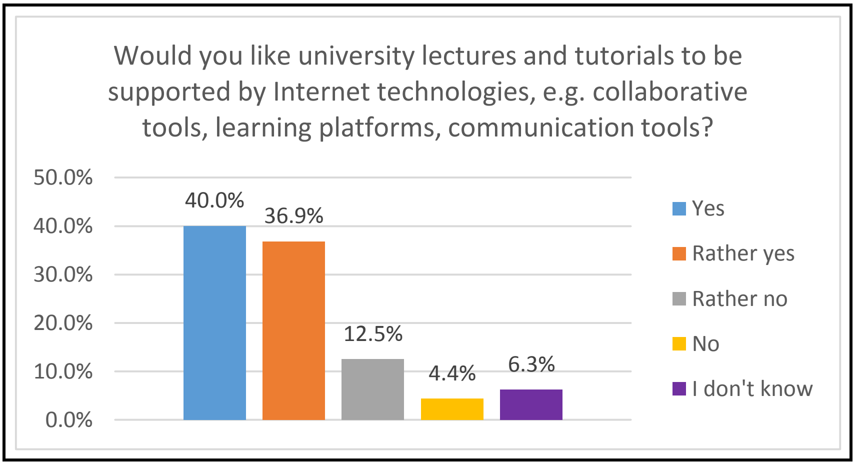

Figure 7. Internet-Supported University Classes
Source: Own work

According to the students, university staff should teach from both traditional textbooks and online materials (Figure 8). Just over 30% of the respondents regard Interned-based resources/activities as more convenient to learn from than paper-based ones versus 41.9% who think just the opposite. These responses are consistent with their answers to question 2, which confirms that they perceive web-enhanced learning as engaging (Figure 2).

When it comes to the frequency of use of online materials at university, the answers also show consistency with those to question 6, which was about using them at the secondary school level (Figures 9 and 6). The most frequently selected options were 'every week' and 'every 2-3 weeks' (24.4% and 35% respectively). Only 11.3% did not have an opinion and 5.6% would not like to use them at all.

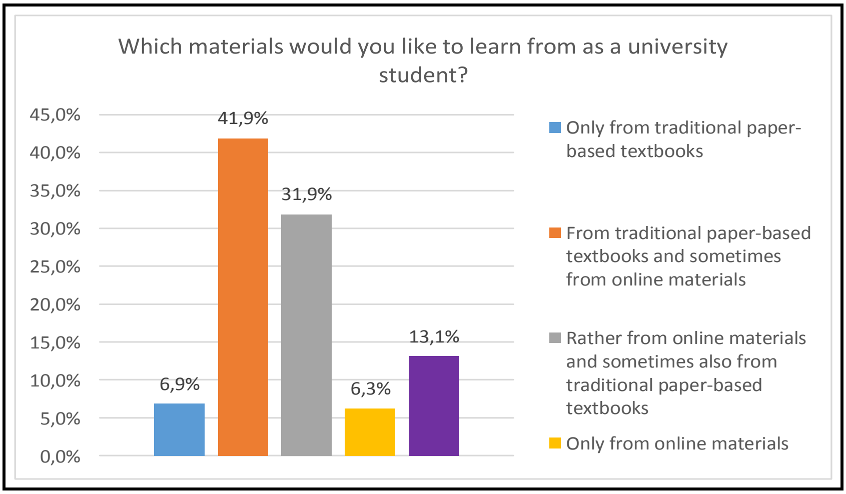

Figure 8. Online Materials in University Education – Preferences
Source: Own work

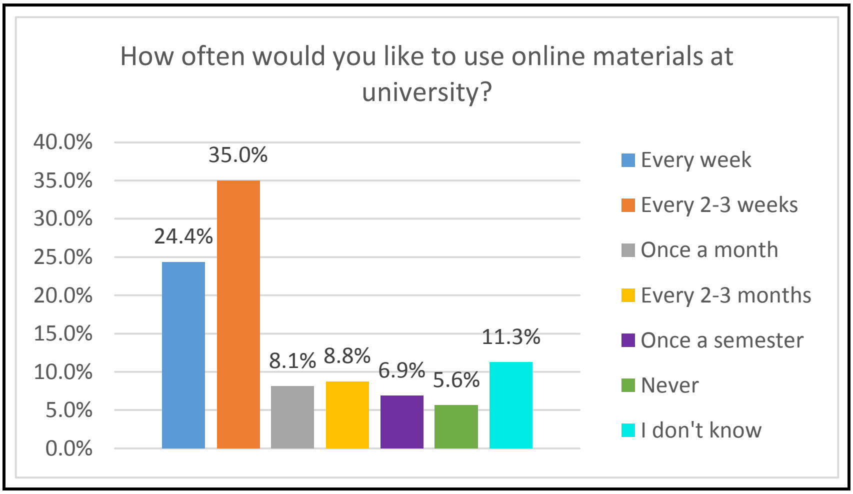

Figure 9. Online Materials in University Education – Frequency of Use Preferences
Source: Own work

Figure 10 shows the distribution of the attitudes to the question of mobile technology use in academic education. More than half of the respondents think that mobile technology should support university courses. Again only 7% cannot see its value, and 5.1% has no opinion. The answers indicate that young people expect higher education institutions to structure their curricula around the technologies they use in everyday life, and that they would like to have more opportunities to learn from Internet-based materials than they have at the secondary school level.

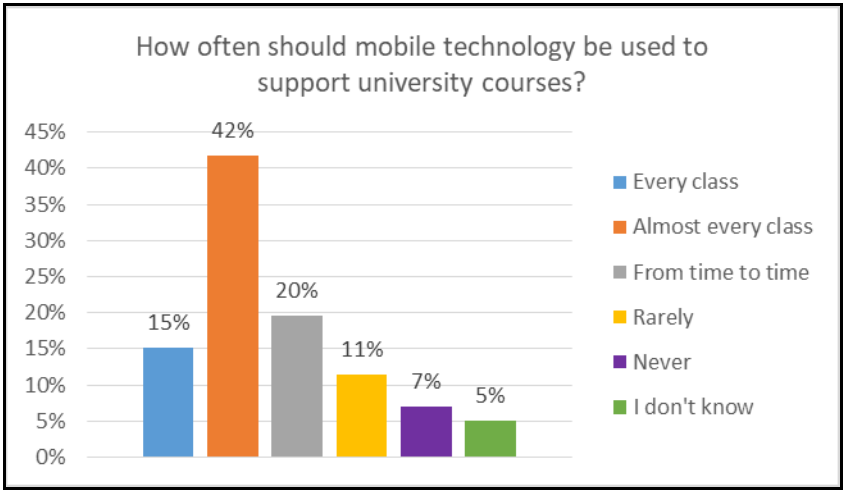

Figure 10. Mobile Technology in Academic Education – Frequency of Use Preferences
Source: Own work

CONCLUSION

The research has shown that Generation Z members are looking forward to educational programmes supplemented by web-based tasks, which may stimulate better engagement in course activities. They can motivate them to develop various hard skills, but also soft ones, which other phases of the research have revealed (Mokwa-Tarnowska, Roszak and Kołodziejczak 2018). Online projects can help improve collaborative, analytical and critical thinking competencies, which has been observed in the students of Gdansk University of Technology participating in classes supported with online tools over the last three years. It has to be emphasized that it is not web-based education itself that stimulates young learners but it is the nature of the online environment introduced that contributes to students' satisfaction with being engaged in an innovative learning experience (Mokwa-Tarnowska 2017). It is the structure of the assignment, usually of analytical and collaborative character, that adds value to learning and teaching. Instructivist education no matter in which environment it is conducted, whether traditional or online, will not engage a new generation of digital natives. They should be encouraged to build mental models in a constructive classroom, which focuses on personal preferences and adapts to learning needs.

Since using Web 2.0 tools to enhance secondary school education is a relatively new phenomenon, only limited research has been conducted on their impact on knowledge and skills development. One of the most thorough research that has been done focuses on an increase in language competencies, and it has shown that online tools engage students in learning and help them build vocabulary and improve grammar proficiency (Kaprocka-Gral 2019, Meier 2019, Łukasik 2018). The research findings presented in this paper show that a majority of secondary school students treat web-based activities as a valuable addition to regular traditional classes, both at the level at which they are studying now and at the academic one, and they would like to be involved in them on a regular basis.

A carefully structured educational environment based on a constructivist approach can result in better learning outcomes, measured in a traditional way or by instruments available through the use of online tools. However, it is not sufficient to add some online activities in class and beyond it. Teachers should learn how to use Web 2.0 tools and activities developed with them to achieve a synergistic effect. Most of them are still using an online environment in an instructive way, usually by adding some text and picture-based components to traditional, paper tasks, and/or to test students' knowledge – prior to what they are expected to learn in class or the one just developed in class. Pyżalski, Zdrodowska, Tomczyk, and Abramczuk (2019, 44-45) in the analysis of their findings state that a majority of the students they surveyed, from 90 Polish schools, could not describe an interesting lesson supported by ICT which they remembered. They also stress that rarely are teachers' competencies to use Internet technologies, mobile technology or even interactive whiteboards evaluated, and little research into this field has not been done (2019, 43).

Secondary school students have high expectations about online tools and mobile technology to support university courses. Research has shown that web-enhanced academic education in Poland is still a novelty (Roszak, Mokwa-Tarnowska, Kołodziejczak 2019, 2018). Like secondary-school teachers, university and college staff use Internet-based resources to provide additional information and data, and to communicate with students. All higher education institutions have learning platforms, but they are frequently used as information boards and for self-tests. Hardly ever are they used for collaborative tasks that focus on developing hard and soft skills (Mokwa-Tarnowska, Roszak and Kołodziejczak 2018). Moreover, the number of academic staff involved in developing e-learning materials and web-enhanced education, regardless of university type, is not satisfactory. Training programmes on content creation and online pedagogy should be conducted, and teachers should be provided with IT support. Having advanced skills in online-based education and knowledge about new learning and teaching environments, academic staff will be able to meet the needs and expectations of Generation Z. Currently many courses offered by Polish universities are still of instructive, uncollaborative nature, and they are run in a traditional environment.

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SUCCESSFUL E-LEARNING: INTERCULTURAL DEVELOPMENT IN GPE'S GLOBAL UNDERSTANDING PROJECT

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Abstract: *This paper presents the learning outcomes of the Global Understanding (GU) project, run and coordinated by the Global Partners in Education (GPE), an organisation established to create educational and research opportunities for member institutions. The GU project involves the use of telecollaboration as a means of developing students' intercultural (IC) competence. The author discusses the learning outcomes of the GU project, as evidenced by survey-based data collected from the participants with regard to cognitive, behavioural and attitudinal components of intercultural intelligence and IC intelligence.*

Keywords: e-learning, telecollaboration, intercultural competence, Global Understanding, learning outcomes.

INTRODUCTION

"Virtual exchanges are technology-enabled, sustained, people-to-people education programs" (Virtual Exchange Coalition 2019). The UniCollaboration (2019) website, defines Virtual Exchange (VE) simply as "(...) (telecollaboration) that is: technology-enabled, sustained, people-to-people dialogues which use new media platforms", while the EVOLVE (2019) website describes it as "(...) a form of computer-mediated learning whereby students from geographically remote classes work together online (in pairs or small groups) on learning tasks developed by teachers or educational facilitators".

All in all, it may be stated that in educational settings VE involves the use of telecollaboration, i.e. teamwork, facilitated by means of information and communication technologies, whereby a common goal is achieved which fosters, or results in, learning.

As O'Rourke (2016) suggests, over the past twenty years telecollaboration has developed from a niche educational practice that it used to be into a commonly used pedagogical solution. As he observes, the reasons for which telecollaborative learning is being used to such a great extent today are numerous. Firstly, telecollaboration is the mode in which professionals ubiquitously work today. Secondly, it assists societies in disseminating and interpreting knowledge. Thirdly, it involves the use of technologies that students use routinely on a daily basis. Thus, it constitutes a seemingly perfect environment in which students can learn by interacting with their online partners.

In the light of the above, it is far from surprising that telecollaboration is being implemented at all levels of education, "from kindergarten through university" (European Commission 2018a) and that it has begun to break the boundaries of its major domain so far, i.e. language studies (Jager, Kurek, O'Rourke 2016). Hence, one can easily find VE projects today in areas such as: "Geography, History, Translation, Public, Administration, Political Science, Cultural Studies, and Foreign Relations" (Jager, Kurek, O'Rourke 2016, p. 11).

Traditionally, telecollaboration has been implemented as a form of intercultural education (cf. Marczak 2013; O'Dowd 2018), and it has been used either to supplement real life exchanges or to substitute for them (O'Rourke 2016; European Commission 2018) in circumstances where international travel is difficult or downright impossible.

As Hagley (2016) remarks, virtual exchanges resolve the problem of monocultural classes, which lack contact with representatives of other cultures by permitting students to involve in virtual mobility and collaborate with colleagues from distant locations. He also confirms that, as a teaching and learning mode, VE is an effective solution through which students' communication skills and cultural awareness can be developed.

Chen and Yang (2014) report on their research results which confirm a number of learning outcomes – based on Byram's (1997) classic model of intercultural competence – likely to result from telecollaborative learning. Their data indicate that – in students' views – telecollaboration may facilitate the development of:

- knowledge of one's own culture and partners' culture;
- intercultural attitudes, e.g. an attitude of curiosity and openness to learning about one's own culture and partners' culture;
- skills of discovery and interaction: the ability to acquire new knowledge of a culture through interaction with others in real time;
- critical cultural awareness: ability to evaluate a particular culture;

However, students in the same study also reported other learning gains from the telecollaboration in which they had participated, including language skills, ICT skills, and collaboration skills. As it can be seen, these could be labelled as transferrable skills which will equip students for their professional lives, irrespective of the actual career path they choose to follow.

To demonstrate how telecollaborative projects can be implemented, the Global Partners in Education Global Understanding project is discussed below, together with its goals, procedures and outcomes.

1. IMPLEMENTING OF INTERCULTURAL TELECOLLABORATIVE LEARNING: THE GPE GLOBAL UNDERSTANDING PROJECT

1.1 Global Partners in Education (GPE)

Global Partners in Education is an international organization promoting educational collaboration between academic institutions located worldwide. Its scope of interest comprises the organisation and administration of a number of ventures, including discipline-specific semester courses, course modules, research projects and the Global Understanding – a telecollaborative intercultural course. GPE was established in the year 2007 at East Carolina University in Greenville, North Carolina, USA and is administrated by ECU’s Global Academic Initiatives.

GPE, which currently unites 45 educational institutions from 25 different countries, aims to promote intercultural education, the use of new technologies in education, create collaboration opportunities for its member institutions and facilitate joint inter-institutional research activities. Most importantly, however, its goal is to support quality performance in its flagship virtual learning project – Global Understanding.

1.2 Global Understanding (GU)

The Global Understanding project constitutes the foundation of GPE in that the former preceded the latter. In fact, GPE per se was launched by universities involved in the initial iterations of the GU project (GPE 2014a).

Global Understanding was piloted by East Carolina University in the year 2003, and in 2004 the first official edition of the project was held. The project aims to develop students' intercultural competence, including a range of knowledge, skills, attitudes and awareness. According to Leibowitz and Luchsinger (2013), the project is supposed to promote cross-cultural communication, permit collaboration with representatives of other cultures and help the participants perceive the world from another perspective.

The project involves international student-student collaboration realised by means of digital technologies, which are used both inside and outside the classroom. In-class work takes place in a synchronous mode and involves videoconferencing, chat, Web communicators, while out-of-class work may involve a combination of telecollaboration performed in both synchronous (online chat, audio-video communicators, social networking) and asynchronous (email) modes (GPE 2014b).

In-class meetings may involve sessions of different length: 50 minutes long, 75 minutes long and two hours long, depending on the circumstances in which particular project partners function. Classes at the partner institutions are synchronised to permit synchronous communication (GPE 2014b).

In every in-class meeting, students in each classroom are divided into two groups. While one of them participates in a group videoconferencing session which permits audio-video communication via a videoconferencing system (e.g. Polycom) or a videoconferencing platform (e.g. Zoom), the other works in individual partner chat via an Internet Relay Chat (IRC) tool (e.g. IceChat). However, the groups alternate both work modes from class to class, so that all students are given an opportunity to gain experience in videoconferencing and chat (GPE 2014b).

As the *GPE Core 2015* (GPE 2014b) document stipulates, particular institutions are partnered with institutions from abroad and project meetings are set by the master schedule, which is announced before an edition of the GPE GU project begins. The number of partners each member institution has in a single edition of the GPE project, i.e. in each academic year, depends on its logistic and educational circumstances, e.g. the availability of adequate equipment and IT support as well as provisions made in particular course programmes and the timetable to be followed.

A total of six linking days must be held between each pair of partner institutions, but additional hours may be devoted to local in-class work, which could be used for pre-linking work and follow-up work.

The linking days are devoted to the discussion of core project topics, which include:

- College Life;
- Family and Cultural Traditions;
- Meaning of Life and Religion;
- Stereotypes and Prejudices;
- Free Topic.

Out of class work is largely devoted to the performance of what is called the *Telecollaborative Project*. The project is usually completed by pairs of students from` the partner institutions; it may happen, however, that students work in groups of three, but even in that case each partner institution is represented by at least one student (GPE 2014b).

The idea beyond the collaborative project is to involve students in work which requires the preparation of a negotiated product, which usually is a multimedia presentation illustrating the project partners' perspectives on selected aspects of culture. What is interesting, while delivering the final presentation the students present one another's perspectives, which requires not only a mere exchange of information but also a degree of reflection and readiness to understand other people's vantage point (GPE 2014b).

The *GPE Core 2015* (GPE 2014b) provides a provisional list of topics for the telecollaborative project. which include *inter alia*:

> "1) Describe your life at 35.
>
> Global Question/Negotiation Product (GQ/NP): What do most people around the world want in life by their mid 30s? (...)
>
> 3) How do you define success in life?
>
> (GQ/NP): What might be a global definition of success? (...)
>
> 5) Choose a song to share with your partner. Describe what it means to you, and how it reflects an aspect of your culture (e.g., College Life, Family and Cultural Traditions, Religion and the Meaning of Life, etc.). Is there a typical dance that goes with this music? How does the music reinforce the message (e.g., melancholy music for song about breaking up)?
>
> (GQ/NP): Together, write lyrics to a song that reflects something that is important to both of you.
>
> 6) Discuss your culture's nursery rhymes/traditional children's songs. Identify several ones and what they show about the country's attitudes and values.
>
> (GQ/NP): Together, write a folktale/nursery rhyme/traditional children's song that reflects something you both value."
>
> (GPE 2014b, p. 17)

As it can be seen above, the topics are varied and they each consist of two components: a general theme to guide the project work and a question to which partner students attempt to provide an answer or the final product, which can be, e.g. song lyrics or a nursery rhyme. All in all, the topics are to stimulate students' active involvement in intercultural exchanges, informed reflection but also creativity. The collaborative project is supposed to permit intercultural learning which the students would really enjoy.

Again, this part of the GPE GU project is student-centred, thus the students involved take decisions about the actual topics which they choose to follow, the tools they utilise to communicate in the course of the project and the work modes they engage in. Partner teachers are on stand-by, ready to help with the topic choice or provide any other kind of assistance, but they only play a facilitative and advisory role (GPE 2014b).

The telecollaborative project is worked on out-of-class, with partner students being able to utilise synchronous and asynchronous online communication tools to proceed with the project work, and ends with the delivery of the final multimedia presentations on the final linking day.

The presentations are supposed to contain a total of 4-6 slides: 2 slides to present individual students' cultural perspectives (presented by their project partners), one slide featuring a tabular summary of the cultural similarities and differences discovered in the course of the project work, and 1 slide containing the students' answer to the global question.

A number of important issues relating to the GPE GU project work at large must be made at this point.

Firstly, as the project is designed to be heavily student-centred, the topics are formulated very broadly so that they can serve as starting points for further intercultural discussion. To what extent students stick to the topics and whether they digress and ultimately direct the discussion towards other issues remains largely at the students' discretion.

Secondly, students are given the opportunity to work on the same topics in videoconference or in chat so that they each can contribute to the discussion, irrespective of the level of their confidence and language competence. It is possible because the synchronous mode favours students with higher levels of confidence, while the asynchronous mode permits contribution from those students who might feel intimidated performing in real time in front of a group.

Thirdly, the format and content of the free topic class may be negotiated by particular partners but in the *GPE Core 2015* (GPE 2014b) it is recommended that the day is used for the presentation of the outcome of collaborative project work performed by the students out of class.

Fourthly, the GPE GU project places a very strong emphasis on systemic reflection on the intercultural experience that the project participants become a part of. *GPE Core 2015* (GPE 2014b) states that students should be encouraged to record their intercultural experience, e.g. by means of a blog, discussion forum or a personal journal. Students are encouraged to reflect on each linking day with regard to:

- "Highlights of discussion of the day.
- Surprising comments or attitudes of classmates & partners at both universities .
- Thoughts on the day’s discussions" .

(GPE 2014b, p. 5)

It is particularly important that reflection on experience does happen; otherwise, students' work may be limited to a mere exchange of standpoints on the issues at hand and the furthering of stereotypes by involvement in a superficial identification of intercultural similarities and differences between the project partners. To what extent, genuine intercultural development occurs in the course of the project depends on its actual implementations at individual partner institutions. That is why, the GPE GU documents leave room for student and teacher independence in decision-taking as intercultural education cannot be simply sanctioned, it may only be stimulated and facilitated by provisions which are conducive to students' intercultural development.

2. THE LEARNING OUTCOMES OF THE GPE GU PROJECT: EVIDENCING STUDENTS' LEARNING GAINS IN THE GPE GU PROJECT

The potential learning outcomes of the GPE GU project were measured on two levels: local and global. At the local level, an attempt was made at gathering students' reports on their perceived learning gains in a particular context, which was achieved by surveying students who participated in the 2017/2018 edition of the GPE GU project at one institution only, which was the Chair of Translation Studies and Intercultural Communication at the Jagiellonian University in Kraków, Poland. At the global level, however, all the participants of the 11th (2017/2018) edition of GPE GU project were pre- and post-surveyed to measure their perceptions of the potential benefits that the project participation had brought them. The reason for examining the learning gains at both levels was two-fold.

Firstly, since teachers and students participating in the GPE GU project exercise are fairly autonomous in how they perform the project work and the details of the actual learning experience at particular institutions are likely to differ, the local context serves as a cross-sectional image of how the GPE GU project may potentially be implemented. Yet, by no means should it be treated as representative of all the other contexts. In effect, although it provides some insight into the manner in which the GP GU project may work, it cannot serve as a basis for any generalisations.

Secondly, in the light of the above, it appeared desirable to present data which would provide a more general picture of how the GPE GU project functioned and what learning gains it was believed to generate on a much larger scale, i.e. in the eyes of a broad population of students who had been involved in the 11th iteration of GPE GU.

As a result, one can gain a better understanding of how the GPE GU project is likely to benefit its participants at large, while also being able to analyse a cross-section of the project work.

2.1. Local context: Students' perspectives on learning gains

The learning context and research sample. As it has been mentioned before, the local data were gathered in the Chair for Translation Studies and Intercultural Communication at the Jagiellonian University in Kraków, Poland, where the participants of the GPE GU project were student translators in their first year of an MA programme in Translation Studies. The students took part in the project as part of an elective course entitled *Intercultural Communication in the New Media*, whose goal was to develop the students' intercultural competence and intercultural communication skills with a view to equipping them better for their future roles as intercultural mediators in the language provision industry, where they would potentially work as e.g. translators, interpreters as well as international project managers. 13 students (N=13) participated in the project, and they were all involved in the research. They were all in their mid-twenties; 11 of them were females (N=11) and 2 were males (N=2).

Research goals, method and instrument. The research goal of the study at the local level was to gain insight into the Jagiellonian University students' learning gains from their participation in the 11th edition of the GPE GU project by gathering their individual, retrospective reflections on selected intercultural experiences that they were asked to report on. Thus, the research involved participant observation in the course of which students' retrospective reports of intercultural incidents yielded descriptive data in the form of close- and open-ended written responses, which were subjected to qualitative (for open-ended questions) and quantitative (for close-ended questions) analysis.

The Autobiography of Intercultural Encounters (Council of Europe 2009) was used as the research instrument. It is a ready-made document which is to help students foster the development of their intercultural competence by making them reflect on actual instances of intercultural encounters and intercultural incidents. The document contains a number of questions through which students can look at intercultural experiences in retrospect, break the situations in question into parts, reflect, objectivise and conclude on what actions to take in similar circumstances, should a given intercultural incident repeat in the future. Individual students were asked to fill out pages 6/20-13/20 of the document, which stimulated reflection on the very intercultural encounter (*The encounter* section), the other person or people involved in the encounter (*The other person or people*), the given student's feelings at the time of the encounter (*Your feelings*), the feelings of any other people involved (*The other person's feelings*), and the possible similarities and disparities between the thought patterns and feelings of all those involved in the encounter (*Same or different*) (cf. Council of Europe 2009 for details).

Individual responses to the questions contained in the *Autobiography of Intercultural Encounters* were analysed and scoured for information relating to the following: (i) the feelings the students experienced at the time of their intercultural encounters; (ii) the actions they took to handle the incidents they experienced; (iii) the significant verbal and nonverbal clues the students used to judge the other party's active involvement, or lack of involvement, in the project tasks; and (iv) perceived learning gains. Therefore, the above-cited elements may be viewed as the operationalisation of successful e-learning adopted for this part of the research. The responses were grouped within relevant categories and analysed for regularities, which produced the final results.

2.1.1 Results

Feelings. The results of the research revealed that the most frequently experienced feelings during the project were: disappointment (8 students, 27%) and surprise (7 students, 23.3%). The range of other feelings that were reported to have been experienced by lower proportions of the participants included: anger, shock, sadness, and pleasure (2 students each), as well as hurting, a scare to ask further questions, frustration, irritation, perplexity and disrespect (1 student each). What shows is that the majority (12 in total) of the feelings evoked by the students' intercultural encounters in the course of the project were negative, while only two of them were positive.

However, it must be underlined that such negative feelings do not – by any means – indicate failure. In fact, quite the opposite may be true; negative feelings experienced in intercultural interactions provide room for learning as they bring to light disparities between cultures, other people's thinking patterns, believes and attitudes as well as areas of potential conflict in intercultural communication. In other words, room for reflection is created, which may result in metacognitive and cognitive development, attitudinal shifts or modifications in communicative behaviour, which are all part of intercultural learning.

Actions taken. The actions that the students took to handle the intercultural incidents that they faced in the course of the project included: asking questions in order to learn more, online information searching in order to explore cultural phenomena (e.g. gun possession in the USA), speaking openly about taboo topics, trying to find common ground (bonding), and trying to rehabilitate their own culture to counteract their project partners' negative perceptions of it. There were also behaviours through which particular students attempted to continue their conversation with the project partners without acting on the problems experienced, e.g. by continuing the conversation regardless, pretending there were no issues involved and avoiding exploration of cultural issues in order not to confuse the project partners.

Thus, two stances on intercultural incidents were identified: pro-active behaviour displayed in an attempt to mediate intercultural differences and ignorance of difference. While the former can be considered as a form of intercultural mediation and learning, the latter is not likely to been conducive to the students' intercultural development.

(Non)verbal clues used to judge the other party's involvement. The markers by which the participants reportedly judged their project partners' involvement in the tasks at hand involved: visual cues, e.g. body language (yawning, stretching), gestures, facial expressions, and eye contact, which were perceptible in synchronous audio-video communication formats (videoconferencing), and audio cues, e.g. the tone of the voice, which were noticeable in synchronous audio-video and audio-only communication. Interestingly enough, the students judged partners' involvement also by the degree to which partners had prepared for a given task or active performance. In other words, they treated their partners' actual in-project actions as evidence of involvement.

While all of the conceptualisations of involvement reported by the students may have been right, it is worth underlining that the conceptualisations themselves were very subjective and may be attributed to individual student traits or cultural differences between them. Again, the very conceptualisations might have led to intercultural learning; yet, much depends on how far individual students went trying to reflect on their perceptions of involvement and their interpretations of their partners' behaviour.

The *learning gains* that the students reported retrospectively can be ascribed to a number of categories, including: cognitive, attitudinal, pragmatic, behavioural and affective.

The *(meta)cognitive gains* reported by the students included the opportunity that the project assignments created for learning about representatives of other cultures and other people, their own colleagues and themselves, e.g. how students could, or could not, cope with uncooperative partners. Some students also realised that their vision of the world was to a large extent shaped by their own beliefs.

The *attitudinal gains* which the students reported were triggered by their new realisations about the world, other people, other cultures, themselves and intercultural learning, *per se*. In effect, the participants reported that the project experience had made them more open towards other people, changed their view of other peoples (e.g. the Americans) and their attitude to the world.

The students also maintained that after the project they felt readier to be more watchful and consider which views originating from the culture they lived in might narrow their vision of the world. They added that they had increased their awareness of the fact that what one person takes for granted may not be recognised as such by another person at all, and there is no one to blame in such a case. Thus, the students declared they would try harder to understand their future project partners' perspectives.

The students also stated that after the project they had more appreciation for both the good and disappointing aspects of their project partners' attitudes and behaviours as both increased the students' cultural awareness. Very much in the same vein, some students stated that if they met a person from another culture, they would not only try to display more curiosity about the other, but they would also bear in mind that other people's different opinions originated from their different cultural background.

The *pragmatic gains* identified within the students' responses regarded the development of receptive and productive language skills. Thus, the students believed the project had given them the opportunity to listen to native speaker English, e.g. an American accent, and practise speaking skills in English in genuine communicative situations.

The *behavioural gains* the students reported involved the effects that the students' project performance was likely to have on their future behaviour. To begin with, for some students the project work resulted in them feeling ready to increase their engagement in project work to be performed with another GPE partner.

Interestingly enough, for others even the very follow-up work, which was the filling in of the *Autobiography of Intercultural Encounters*, was a lesson to learn, as a result of which they had familiarised themselves with the instrument and believed that they would use the document, out of their own accord, in other projects.

The *affective gains* that transpired through the students' responses related mostly to the positive feelings evoked by the project experience. The students stated that they had enjoyed the project work and found some moments funny. One might expect that such an experience may easily translate into increased overall motivation to involve in other forms of intercultural learning, which will certainly create more opportunities for the students to develop their intercultural competence further.

2.2. Global context: Overview of learning gains in project report data

The context and research sample. The local context discussed above seems to support the statement that the GPE GU project is an example of a successful implementation of the idea of telecollaborative intercultural learning. However, since at each GPE institution the details of the project work may substantially differ, it is desirable to find out to what extent the entire GPE GU project may be perceived as successful. That may be judged on the basis of data collected globally, i.e. from a much larger sample of student participants based at a large number of diverse educational institutions located in different parts of the world. Thus, this part of the present paper contains an analysis of selected results of unpublished survey-based research conducted and outlined in poster format by Eppler (2018) and Eppler and Wynn (2019).

Two iterations of the research will be discussed. The first iteration was conducted in the year 2017 and involved data collected from 1312 students (N=1312) who participated in the 12th edition of the GPE GU project. The students surveyed represented 35 universities from 20 countries located worldwide.

94% of the students surveyed had participated in the GPE GU project for the first time. Out of the 1312 students who took part in the survey, 497 responded to both the pre- and post-surveys (Eppler 2018).

The second iteration of the research was administered in the year 2018 on the basis of data obtained from 1245 students (N=1245) who participated in the 11th edition of the GPE GU project. At the time of the survey the students represented 28 universities from 17 countries located worldwide. 94% of the students surveyed had participated in the GPE GU project for the first time. It is important to observe that out of the 1245 students who took part in the survey, only 603 responded to both the pre- and post-surveys.

While the academic background of the students who participated in the 2017 iteration of the research was not examined, it was done in the 2018 iteration. In the latter case, those students who disclosed their academic background (N=691) represented a wide range of university programmes and majored in areas of study such as: social sciences (25%), business (21%), health and natural sciences (20%), engineering and technology (9%), education (8%), languages (7%), communication (5%) and humanities and fine arts (4%).

Research goals, method and instrument. The goal of this part of the present analysis is to state to what extent the GPE GU project could be considered an example of successful intercultural learning research on the global level. This will be done on the basis of research data which come from two unpublished documents: *Global Understanding (GU) Survey Results Assessment Report Spring 2017 and Fall* 2017 (Eppler 2018) and *Global Understanding (GU) Survey Results Assessment Report Spring 2018 and Fall 2017* (Eppler and Wynn 2019) – each displayed at the annual GPE conference in order to provide an overview of the GPE GU experience, as reported by the student participants.

Eppler's (2018) and Eppler and Wynn's (2019) research was survey-based and cross-sectional in that it involved data collection executed through a pre-course and post-course survey for each of the two iterations of the GPE GU project examined. The information collected concerned the project participants' profile, their project experience, the challenges that they faced and a variety of perceived learning gains, including the development of the students' Cultural Intelligence (CQ). The CQ scale comprised a set of 20 questions in total which fell into 4 categories that measured: knowledge (metacognitive and cognitive), motivation and behaviour. The CQ scale questions can be consulted in a publication by Ang et al. (2007) from which they had been excerpted.

The pre- and post-course surveys were administered online in the spring and fall semesters of 2017 and 2018 and contained a number of close-ended and open-ended questions. The online forms were distributed via a custom-designed GPE GU project platform which the project participants accessed through hyperlinks they had obtained from their teachers. The students' participation was voluntary, although their teachers were supposed to strongly recommend to the students that they took both the pre- and post-course survey in each project iteration. The responses were analysed quantitatively for close-ended questions and qualitatively for open-ended questions. In the latter case, individual students' responses were scoured for recurrent themes and response categorised were identified which would illustrate more general trends within the opinions expressed by the survey participants at large.

2.2.1 Results

The results of the survey research which will be discussed here relate most of all to the students' perceived learning gains in terms of: (i) the development of their communication skills; (ii) their experience of collaboration and relations with project partners; (iii) the development of Cultural Intelligence; (iv) interest in further intercultural/international experiences; and (v) course satisfaction. Therefore, the above-cited elements may be viewed as the operationalisation of successful e-learning adopted for this part of the research.

Communication skills. The results obtained revealed that the GPE GU project appears to have contributed in a number of ways to the development of the students' intercultural communication skills. It finds confirmation in the fact that 63% of the students surveyed in 2017 and 61% of the students surveyed in 2018 claimed that after the GPE GU course they felt more competent while interacting with representatives of other cultures. What is more, among the reasons for taking the GPE GU course, which the 2018 respondents listed as write-in options, the second largest response category identified (22% of the 315 of those students who responded to the question) was the development of communication and language skills.

At the same time, 72% of those surveyed in 2017 and 75% of those surveyed in 2018 declared that after the project they felt lower levels of anxiety and fear while interacting with representative of other cultures. In addition, the course apparently also contributed to reducing the students' levels of speaking anxiety at large. 54% of the respondents surveyed in 2017 and 52% of the respondents surveyed in 2018 declared that they felt more competent while speaking in classes, while 64% of those surveyed in 2017 and 65% of those surveyed in 2018 claimed that they felt less anxious about it after the GPE GU course than they did before.

In the same vein, the proportion of students examined in 2018 who claimed that they did not feel anxiety while speaking with their colleagues rose by 11% (from 34% before the course to 45% after the course), as did – by 9% in 2017 and 8% in 2018– the proportion of students who felt confident while speaking in class in general (from 32% before the course to 40% after the course and from 34% before the course to 43% after the course, respectively).

The above-cited benefits of the GPE GU project were unwittingly summarised in a write-in response from the 2018 iteration of the research in which a GPE GU student from India wrote that: "Students should take global understanding course to improve one's communication skills and confidence".

Experience of collaboration and relations with project partners. It seems that the respondents found the GPE GU the tandem project work, which involved the performance of a telecollaborative project in pairs, very interesting because a very large proportion (97.75 in 2017 and 85% in 2018) participated in two or more such projects, while over a half (59% in 2017 and 53% in 2018) participated in three or more projects.

Further support for the apparent success of telecollaborative work in the GPE GU project comes from the vast majority of the respondents (89% in 2017 and 87% in 2018) who stated that they were in favour of that kind of work mode in the GU classes to come. The support for telecollaborative work is even more valid when one realises that the positive opinion about telecollaboration was expressed by such a large proportion of students despite the two most important challenges to telecollaboration:

1. having to negotiate time differences between the partner institutions, which was reported by 57% of the respondents in 2017 and 55% of the respondents in 2018;
2. lack of responsiveness on the part of project partners, reported by 51% of the respondents in 2017 and 50% of the respondents in 2018.

While the former challenge is self-explanatory, the latter might be attributed to a number of factors, e.g. (i) the students' extensive involvement in various forms of virtual learning, within and outside the GPE GU project, which is likely to have worn off the effect of novelty and thus reduced the students' motivation to actively participate in the project assignments, (ii) the lack of systematic supervision on the part of course instructors, or (iii) technical issues. However, the actual explanation is yet to be offered as it remained outside the scope of the GPE GU research conducted so far.

As far as the GPE GU participants' relations with their partners are concerned, the results indicate that the project work creates good opportunities for developing close interpersonal ties. As many as 63% of the respondents in 2017 and 66% of the respondents in 2018 stated that the project had helped them to befriend at least one of their international partners.

What is more, among the overall gains from participating in the project, which were to be enumerated by students as write-in responses to an open-ended question in the 2018 iteration of the research, 10% of them placed friendship. In other words, they declared that the project promoted the making of new friends in foreign countries.

The development of Cultural Intelligence. As far as cultural intelligence is concerned, in both iterations of the research by Eppler (2018) and Eppler and Wynn (2019) no numerical scores were provided but as it is reported by the research authors, each time significant increases in students' pre- and post-course CQ scores were observed. What is more, those increases were observed within each of the components of cultural intelligence, i.e. knowledge (metacognitive and cognitive), motivation and behaviour.

CQ scores also correlated with improved results in the areas that have already been presented, e.g. increased ability to understand other people's perspectives, lowered anxiety levels in interaction with strangers, or more interest in up-to-date cultural knowledge, international travel and foreign study, to name a few.

The CQ scores for individual students were also related to their social profile, which was interpreted as dependent on whether they had international friends prior to the project, and whether they made any new international friends in the course of the project. Four different student profiles in this respect were identified: (i) students with prior friends and no new friends; and (ii) students with prior friends and new friends; (iii) students with no prior friends and no new friends; and (iv) students with no prior friends and new friends; Interestingly enough, those students who had no international friends prior to the project but made new friends in the duration of the project were those who had achieved the highest increase in their CQ scores. As Figure 1 illustrates, their CQ scores increased from 4.83 to 5.25, whereas in the case of the other groups, the increase ranged from 5.3 to 5.46 (for group i), from 5.16 to 5.46 (for group ii) and from 4.75 to 5.09 (for group iv).

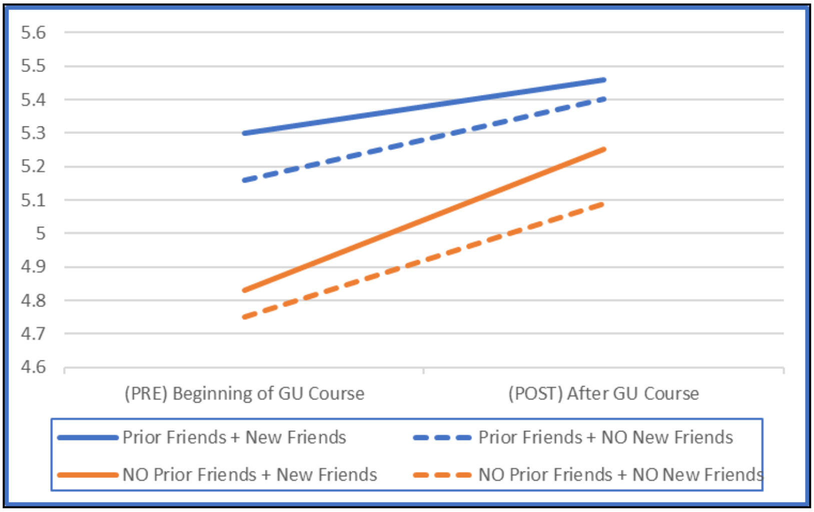

Figure 1. CQ: Prior international friends x making international friends
Source: Eppler & Wynn, 2019

Increased awareness and interest in further intercultural/international experiences. The students reported the facilitative role of the GPE GU project in increasing their intercultural and international awareness. 77% of the respondents surveyed in 2018 declared that the GU course had helped them to understand other people's perspectives (no data were collected in this respect in 2017). 76% of those surveyed in 2017 and 74% of those surveyed in 2018 claimed that through the project they had increased their knowledge about other countries and cultures. 70% of the students surveyed in 2017 and 66% of the students surveyed in 2018 reported that participation in the PGE GU project had increased their interest in following international news. 80% of those surveyed in 2017 and 78% of those surveyed in 2018 reported increased interest in international travel, while 70% of those surveyed in 2018 expressed increased interest in studying abroad (no data were collected in this respect in 2017). A graphic summary of the results is presented in Figure 2.

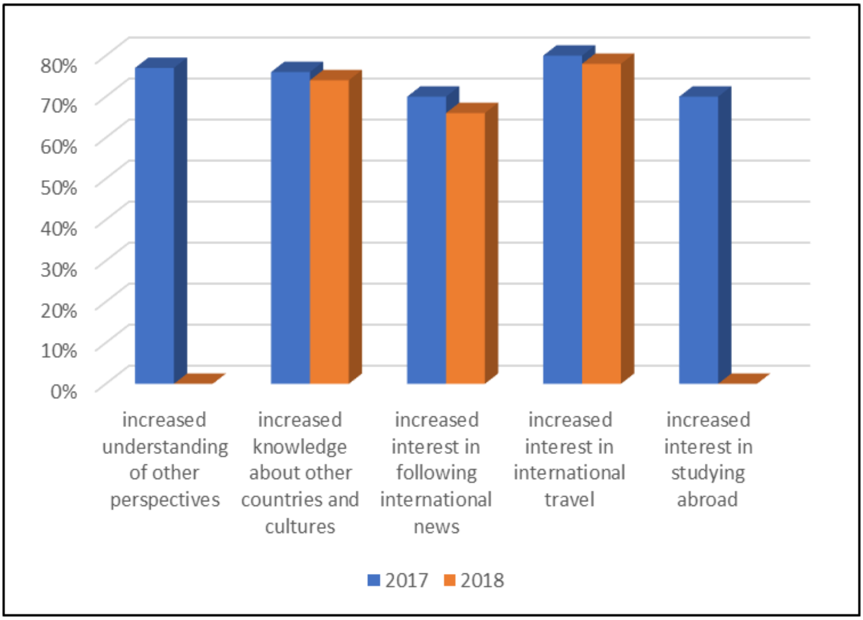

Figure 2. Impact of the GPE GU project on intercultural/intercultural awareness

Source: Own work based on Eppler, 2018 and Eppler & Wynn, 2019

Clear increases were also identified in the students' interest in seeking international/intercultural experiences. For instance, the proportion of those who reported increased effort to learn about other countries and cultures in their free time rose from 31% before the GPE GU course to 37% at the end of the course (as revealed by the 2017 data), and from 33% before the GPE GU course to 42% at the end of the course (as revealed by the 2018 data).

The pre-course average rating of the students' anxiety relating to the prospect of living abroad, which the students indicated on a stress scale ranging from 0 to 10 in the 2017 research and a scale ranging from 1 to 7 in the 2018 research, had significantly decreased from 5.05 at the beginning of the course to 4.78 by the end of the course and from 3.72 at the beginning of the course to 3.52 by the end of the course, respectively.

Last but not least, the proportion of those students who considered the idea of studying abroad, or those who were planning to do so, had risen from 38% at the beginning of the course to 43% by the end of the course in the 2017 research, and from 25% at the beginning of the course to 34% by the end of the course in the 2018 research.

Course satisfaction seems to have reached substantially high levels for nearly 80% of the respondents in each iteration of the research, which manifests itself in the fact that on a scale ranging from 1 to 7 points, they marked their satisfaction level either as 6 (40% in 2017 and 41% in 2018) or 7 (39% in 2017 and 36% in 2018).

Moreover, a vast majority (89% in 2017 and 87% in 2018) of the students maintained that they had already recommended the GPE GU project to their colleagues, while a similarly high proportion (87% in 2017 and 86% in 2018) expressed interest in participating in other intercultural learning courses of the GPE GU type.

As a GPE GU student from Lebanon stated in the 2018 research, he/she would recommend the course to others *(...) because it was the most interesting course in my time at uni*, which seems to confirm the role that the GPE GU course plays in diversifying students' learning experience at university.

CONCLUSION

Local level. What transpires when one looks back at the results obtained in the local research is that the GPE GU project is likely to have created multiple opportunities for intercultural learning, which apparently involved the development of cognitive and metacognitive knowledge. The participants reported that they had not only increased their knowledge of other countries and cultures, their project partners and even their own colleagues (cognitive knowledge) but also the very process of their own intercultural learning (metacognitive knowledge).

The learning gains the students reported also comprised changes to the students': (i) awareness of intercultural differences at individual and more general cultural levels, (ii) attitudes towards strangers and different forms of behaviour, (iii) mindset, i.e. readiness to approach others and intercultural difference with openness, as well as (iv) language skills.

In the local context examined, the project work was reportedly fun, which might have a motivational effect on the students seeking opportunities for further intercultural learning. However, it must be observed that the gains listed by the project participants cannot be taken for granted. Clearly, the project constitutes a learning opportunity but to what extent students take it, depends on how they act upon their project experience. That may be easily seen when one looks at what feelings the students experienced in the project, how they acted upon intercultural incidents and how they interpreted their project partners' behaviour.

The majority of the feelings experienced were negative, at times particular students took action to mediate intercultural conflict, on other occasions they simply ignored it, they also interpreted their project partners' behaviour using their own criteria. All of the above are potentially conducive to intercultural learning. The survey data seem to confirm that at least in the students' view such learning did occur. However, how much of that learning happened in the case of individual students depended largely on the degree to which they took informed and reflection-based decisions, and that – due to the nature of the research conducted – remains opaque. What follows is that the GPE GU project potentially creates a myriad of opportunities for intercultural development but in order to ensure such learning indeed happens at individual level, students must be permanently involved in teacher- or self-induced reflection. Only then will they be able to maximise their learning gains.

Global level. The results collected globally, i.e. from a much larger population of the project participants, also demonstrated a number of positive outcomes.

Firstly, it turned out that the students reported increases in intercultural communication competence and confidence. Interestingly, it was not only increased confidence in interaction with strangers, but also confidence in speaking at large, even in communication with local colleagues. Thus, the project work seems to have stimulated the lowering of the students' speaking anxiety, which is often cited as a barrier to the development of students' productive skills in a foreign language (cf. Cheng, Horwitz & Schallert 1999).

Secondly, the students found the work modes involved in the GPE GU project highly interesting, e.g. the tandem work performed by pairs of students out of class and telecollaboration at large. It is worth adding that the students appreciated telecollaborative work despite the challenges it induced.

Thirdly, the students viewed the project as an opportunity to develop close interpersonal relationships with their project partners. Additionally, it was discovered that the project produced increases in the students' scores on the cultural intelligence scale.

What draws attention here is the fact that although it is impossible to state whether an increase in the students' CQ scores facilitated the in-project friend-making or whether the opposite was true, it nevertheless seems to demonstrate a correlation between CQ and the ability to build relationships with representatives of other cultures. And even though the direction of that influence cannot be established on the basis of the data obtained, the very correlation indicates yet another area for successful intercultural learning within the GPE GU project.

Fourthly, the students declared the project had increased their intercultural awareness and motivated them to seek more intercultural experiences, continue their self-development in the area and undertake new learning opportunities, including foreign language study.

Last but not least, the students reported very high levels of satisfaction with the project and underlined the uniqueness of the GPE Gu course in their study programmes.

All in all, the GPE GU project seems to be an example of successful intercultural learning, at both local and global level. However, it would be interesting to conduct further research into the actual workings of the project and the mechanisms behind the apparent success. For example, it is necessary to find out to what extent and in what manner students' reflection on experience is stimulated in other local contexts, i.e. at other universities. Moreover, it is desirable to verify the project participants' claims about the components of intercultural competence which they claim to have developed in the GPE GU project. In order to respond to this need, future research needs to seek evidence of actual progress in students' intercultural development, instead of examining students' mere declarations.

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MENTORING AS A SIGNIFICANT TOOL IN EDUCATION AT A CZECH UNIVERSITY

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Abstract: *The paper deals with the author's experience in mentoring usage at the Faculty of Military Technology (FMT), University of Defence (UoD) in Brno, the Czech Republic. Firstly, the content of the term mentoring is described. Secondly, the following questions were addressed: why mentoring was used at the FMT UoD, what effects this tool has brought and what can be expected in the future.*

Keywords: mentoring, education, mathematics, university.

INTRODUCTION

Some university study fields, especially technically focused ones, have not enough students. The typical basics of these study fields are mathematics, physics and IT. Moreover, some of their students require a higher attention due to their insufficient knowledge and competencies from secondary schools. On the other hand, graduates of these study fields are strongly required by the contemporary society. The most critical period seems to be the first semester of their study at the university. There is a necessity to find a suitable help for everyone who needs it.

The next text deals with the author's experience in mentoring usage at the Faculty of Military Technology, University of Defence in Brno, the Czech Republic. Among other local initiatives from faculty authorities, mentoring seems to be the most successful tool which enables to overcome study problems of faculty new students.

1. POWER OF MENTORING

1.1 Mentoring Concept

Serving as a mentor brings many challenges and rewards (Reh 2019). The mentor is responsible for providing support to, and feedback on, the person in his or her charge. Mentoring is the process of sharing your knowledge and experience (whatishumanresource.com website on HMR for students, 2019). The collection of mentoring definitions can be found (Gibbons 2017). It can be used in work and academic life. Mentoring is often used in corporate practise (EDOST, s.r.o., 2012). There are also mentoring programs at universities where students receive support for academic work, the right career choice, or starting their own business (Herinková, 2019). Some projects that have benefited students and parents from different cultural or disadvantaged backgrounds and projects that support their development needs are described in (SchoolEducationGateway, 2017).

The term mentoring can be defined as a long-term professional relationship (partnership) focused on supporting the growth and development of the mentee. The mentor (senior or more experienced person) is a guide who gives his/her experience and knowledge in a specific topic or field of knowledge. Transferring of knowledge, suitable approaches and competency is realized in a natural environment, e.g. at school, at workplace. The result is that the mentee can find a proper point of view and a solution of a problem.

The mentor should have main responsibilities as follows:

- assist the mentee in developing talents;
- allow the mentee to grow and become more independent;
- maintain dialogue and discussion, objectivity and balance;
- prepare the content and participate in regular meetings with the mentee;
- accustom the mentee with the values, culture, policies and systems of the organization;
- share information with the mentee about continuing professional development and opportunities;
- provide feedback to mentee and emotional support as needed.

1.2 Mentoring in the Faculty of the University Environment

Mentoring at the Faculty of the University can be described as a mentoring which has its own specifics. It can be beneficial in three main aims:

1) senior academic as a mentor and junior academic as a mentee;
2) academic as a mentor and student as a mentee;

3) student of higher year of study as a mentor and student of lower year of study as a mentee.

A help given in the form of mentoring for the junior academics can be realized in two main aims. A senior academic can be the mentor in the field of teaching and/or a research work and publishing. Close co-operation between older and younger academics can significantly support growth of faculty departments.

Part of the new students can have adaptation and/or study problems due to the different focus of prior learning and knowledge gained. The faculty can offer various forms of tutoring focused on key subjects but a suitable solution can be mentoring or combination of tutoring and mentoring.

Selection of academics who could be good mentors should be realized very carefully. It should be solved with regards to not only a professional focus which is required. The key role is also played by own interest of a concrete teacher to work as a mentor. The whole process of mentoring should be set up and co-ordinated from the faculty level.

The highest needs for mentors can be expected at the faculties with a higher number of students from different culture environments. Especially these students could find mentoring as a significant source of their study success.

1.3 Contemporary ICT Tools and e-Learning for Mentoring

Modern ICT tools and e-Learning play an important role in contemporary education including mentoring. Mentoring should be fully opened to the possible using of modern ICT tools and e-Learning. It is the important mentor's responsibility to select those items of modern technology which can bring the best effects for his/her mentees. On the other hand, each mentor should be familiar with modern ICT tools and appropriate selection and/or recommendations should be done after discussion with his/her mentees.

Similar conditions are valid for the using of e-Learning. Mentors should keep in mind all the scope of various e-Learning courses which are available. The selection and/or recommendation the most suitable ones should be done due to his/her knowledge of personal characteristics and needs of his/her mentees.

The mentor's work should be aimed at the predefined goals of mentoring. Modern ICT tools and e-Learning courses can make the mentoring easier but sometimes more complicated. Personal characteristics and current knowledge and competences of the mentor and his/her mentees are the basis for the mentor's decisions.

What ICT tools and e-Learning courses can be best solution for one group (mentor and a few mentees) is not possible to apply to another group (mentor and a few mentees). Information exchange and discussion the topic of selection of suitable ICT tools and e-Learning courses are irreplaceable.

The faculty should support its mentors in various ways. Firstly, it should enable mentors to request courses which could serve their development and improving of their work with mentees. Secondly, it should regularly organize meetings of faculty mentors with the aim of information exchange and their work assessment. It is not probable that mentors should create new e-Learning courses but they should be informed what they can use and what are the current opinions in the community.

2. MENTORING AT THE FACULTY OF MILITARY TECHNOLOGY OF THE UNIVERSITY OF DEFENCE IN BRNO

2.1 The Way to Mentoring and Setting It Up

The modern military is strongly based on technical devices and appropriately educated people. The Faculty of Military Technology (FMT) is the only technically focused military faculty in the Czech Republic and faculty graduates are in great demand of the Ministry of Defence (MoD) and the Czech Armed Forces (CAF). In the last years the FMT places increased emphasis on continuous five-year study.

New students of the FMT have often study problems in mathematics. In order to radically reduce the number of students who are leaving the faculty during the study, the FMT has been practising mentoring since winter semester of the academic year 2018-2019.

The rules have been set for winter semester as follows:

1) Each department of the FMT provided a few mentors. The main focus of their work was the secondary school mathematics. All the FMT mentors were coordinated by a selected mathematician from the Department of Mathematics and Physics. Recommended topics and examples were given to mentors as a support for their work.
2) Each mentor provided service for approximately 3 students. The main task was counselling on overcoming gaps in secondary school mathematics according to the specific needs of students assigned.
3) The mentor worked with the assigned students regularly at the scheduled time, 2 hours per week.
4) The expected progress of all students (mentees) was tested by the Department of Mathematics and Physics and the data were sent to mentors.

The rules for the summer semester have been modified as follows:

1) Mentoring was extended to secondary school Physics. The mentees whose results of exams in winter semester were better than 2.5, could co-operate with their mentor on the voluntary level. These students could only give information about their study to mentor monthly.

2) Mentees whose results of exams in winter semester were not better than 2.5, co-operated with his/her mentor regularly at the scheduled time, 2 hours per week.

2.2 Results Achieved in the First Year of Mentoring Using

To monitor the influence of mentoring at the FMT UoD in Brno, the author used a research sample comprising 80 military students studying in their first year of study at the FMT UoD. The dataset includes data gained from the following sources:

1) Learning Potential Test (LPT) as a part of the entrance examination of the new students of the FMT UoD;
2) results of two progress tests in Mathematics during the winter semester (September – December 2018), realized by Department of Mathematics and Physics, the FMT UoD;
3) questionnaire survey on respondents' gender, their previous studies, IT skills and work experience during the first lecture of the subject Information Technology (October 2018), realized by the author of the article;
4) the results of Mathematics subject exam and other subject exams and credits which were mandatory in the first semester, available at the information system of the UoD.

The LPT consists of mathematical, logical and spatial imagination tasks. Although the LPT is not focused only on Mathematics, previous study proved that LPT can bring significant information about students' current knowledge and skills in Mathematics. Pearson correlation coefficient demonstrated moderate correlation between the LPT and current knowledge and skills in Mathematics (Hrubý, Staňková, 2019).

The key criterion for the FMT UoD has been fully met. The number of unsuccessful students whose study at the FMT UoD have been stopped in winter semester of the academic year 2018-2019, has been surprisingly very low. The first analysis showed that thanks to the mentoring the number of unsuccessful military students dropped by 75 percent during the first semester.

On the other hand, the author thinks that the mathematics competency needs its own time for being definitely improved. The human brain requires a specific right time and a specific time interval for an adaptation on proper style of mathematical thinking process. Success in winter semester must be confirmed in summer semester of the academic year 2018-2019.

It should be taken into account that academics involved in mentoring did not worked with the same intensity and interest. On the other hand, the most of students highly appreciated the help which was given to them thanks to the mentoring organizers and mentors.

2.3 Possible Future Development of Mentoring at the FMT

The future development of mentoring at the FMT UoD in Brno could comprise a suitable ICT support for the both mentors and mentees (students). In the frame of the ICT support can be expected:

1) special web pages which could serve as a quick primary information source for mentors and students;
2) clear and simple enough system of motivation for mentors and mentees (students) which is electronically published, permanently available and regularly assessed.

It is a necessity to collect data connected to mentoring, analyse them, interpret achieved results and discuss them inside the FMT community. It requires close cooperation of persons in three levels: main organizers (faculty level), mentors – academics (department level), mentees (students of the FMT UoD).

The next aim can be an attempt to transfer the mentors' duties from the academic staff to the best students of the FMT UoD who are in higher year of study. Comparing the work results of academic staff and students in the role of mentor could bring interesting results.

With regards to the necessity to fulfil the planned requirements of applications of new students, the FMT UoD could extend the specific form of mentoring to the secondary schools which could be potential source of the FMT UoD new students.

CONCLUSION

Mentoring can make an important contribution to personal and social growth and to the development of students as well as teachers. The author is convinced that the first year of mentoring has brought the significant positive effects at the FMT UoD in Brno.

Firstly, the new students have received a significant help for the overcoming a secondary school mathematics gap in the right time, that is, in the first semester of their military university study. Secondly, the students could not only improve their mathematics competency but also meet their future lecturers from the various Departments of the FMT UoD in Brno and to discuss mathematics from their practical point of view. Thirdly, students' in time co-operation with academic staff of the Departments of Specialization can accelerate their professional growth and to support their future research work.

The first year of mentoring at the FMT UoD seems to be the most effective measures which significantly reduced the number of failed students.

The contemporary measures should be carefully improved in order to maximize the efficiency of the energy and time involved. Especially e-Learning is a promising technology in the intended direction.

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THE USE OF PORTALS AND LEARNING ENVIRONMENTS IN NON-ACADEMIC TEACHING

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Abstract: *Preparation of future teachers for the efficient use of technologies and their inclusion into the teaching process is one of the major educational objectives in the pedagogical field. The aim of the article was to evaluate the use of portals and educational environments in non-academic teaching. In particular, the research focused on the level and purposes of the use and utility of these types of tools in school education. The article presents the results of a pilot study conducted among second and third year students of Mathematics and Computer Science Teaching at the Faculty of Mathematics and Computer Science, Adam Mickiewicz University in Poznan (AMU) and among experienced teachers. Research shows that teachers are increasingly willing to use IT tools to support teaching, but their knowledge of portals and ready-to-use learning environments is minimal.*

Keywords: learning portals, learning environmets, ICT competences, teaching

INTRODUCTION

The development of technology has introduced many changes into the educational field. Although still popular, the traditional classroom with a blackboard and chalk is slowly becoming a thing of the past. School workrooms are now equipped with laptops, projectors, interactive boards, electronic textbooks and access to the Internet. Such are the requirements of the new educational standards and of the new generations of students growing up with the latest technologies. The next step are the integrated educational communities that are still associated only with distant education. They create an educational and communicative space that supports the development of both social competences and individualized education. (Jukes, McCain, Crockett 2010; Kivunja 2014; Prensky 2010: 98-109).

1. LEARNING ENVIRONMENTS

1.1 Educational portals

An example of such environments are educational portals equipped with synchronous (chat, video conferencing) and asynchronous (e-mail, forum) communication tools (Kołodziejczak, Roszak, Ren-Kurc, Kowalewski, Półjanowicz 2015) that have mechanisms for creating and supervising project groups and tools for co-creation of educational content (Kołodziejczak, Roszak, Kowalewski, Ren-Kurc 2014). The built-in functionality of these applications allows evaluation of students' knowledge and the teaching process. It is also possible to track students' progress and provide feedback (Kołodziejczak, Roszak, Ren-Kurc, Kowalewski, Bręborowicz 2016). Besides, the possibility of adding simple educational games and a system of badges make the portals a tool of gamification (Krasnova, Cewińska 2014; Lee, Hammer 2011). Common access to the Internet allows free access to the portals not only in the school building but also outside. Attractive materials supplementing the content provided during the lesson, a system of tips and hints for homework, the ability to check knowledge before the test are just some of the uses of portals after lessons. As can be seen, the only limit is the teacher's imagination. In addition, platform hosts (e.g. Moodle) offer additional functionalities exclusively for schools, such as the printing of diplomas, an electronic diary and automated creation of schedules (An e-learning platform for schools).

1.2 Google Classroom environment

A tool for creating an educational environment that is easier to use both for the teacher and the student is Google Classroom – a free Google service for schools, colleges, non-profit organizations and individual users with a Google account (Manage teaching and learning with Classroom). Google Classroom allows the teacher to create virtual classes that reflect real-life classes, project groups or other teamwork depending on the need. Classes are built in a so-called stream that operates as an information board on which it is possible to create questions, post announcements and assignments that can be sent out, commented and evaluated by the teacher also in real time (Figure 1). The stream of classes also acts as a communicator between participants – the teachers and students. In addition, Google Classroom works with other Google services, such as Documents, Calendar, Gmail and Google Drive. An interesting option of this tool is the ability to add a "guardian" for each student individually. This functionality is created to enable parents to follow their child's progress on a regular basis. After confirming the invitation the parents will receive information about missed and upcoming assignments and the child's activity during the classes sent to their email address.

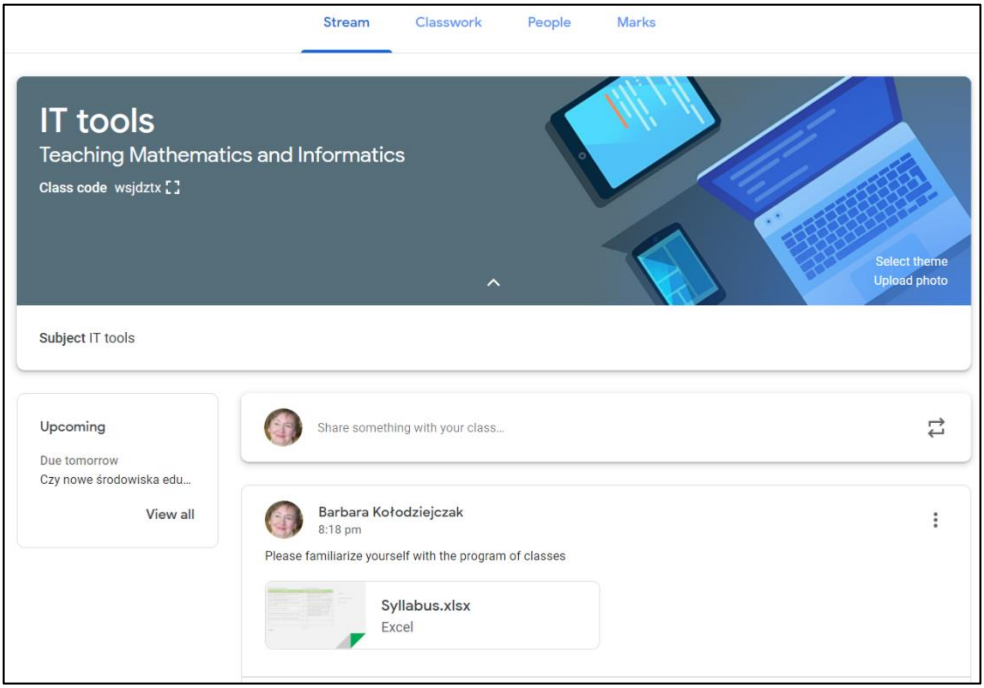

Figure 1. Classes in the Google Classroom environment
Source: Own work

1.3 Microsoft Teams environment

A similar, although slightly more extensive service, called Microsoft Teams is offered by Microsoft for Office subscribers (Microsoft Teams). This service was originally aimed at businesses, however, it is now also available with educational Office licenses (Tools for limitless learning). Access to MS Teams is possible through a Web browser, desktop or mobile application. The educational service offers the possibility of creating classes (app Teams), communicating using chat, audio and video conferencing (app Chat), managing private and shared MS Teams files (app Files), scheduling meetings (app Meetings), tracking changes in all groups, forums and other user activities (app Activity) and managing the assessed tasks (app Assignments for teachers).

The user community of MS Teams is divided into groups in which channels can be added. Their number and purpose depends on the needs. For example, channels can be created within a class for interest or design groups, or the teacher can create thematic channels within the subject taught, e.g. geometry or algebra. Teams and channels have their own work area equipped with three standard tools (available in separate bookmarks): *Conversations*, *Files* and *Notes*. *Conversation* is a forum type of group members with the possibility of sharing documents, multimedia and audio and video conferencing (Figure 2). *Files* is a repository of files shared by team members in a given channel. *Notes* is a place for notes, attachments, links and audio-video files shared by students and teachers. The addition of other tools depends on the teacher or student's needs. In the General channel, which is obligatory for each team, the *Assignments* tool is available to build rated tasks and to send feedback to the student. After publication the assignment will be made available to students on a specific date and time as an element of the Conversation stream (Microsoft Teams for Education training videos and resources).

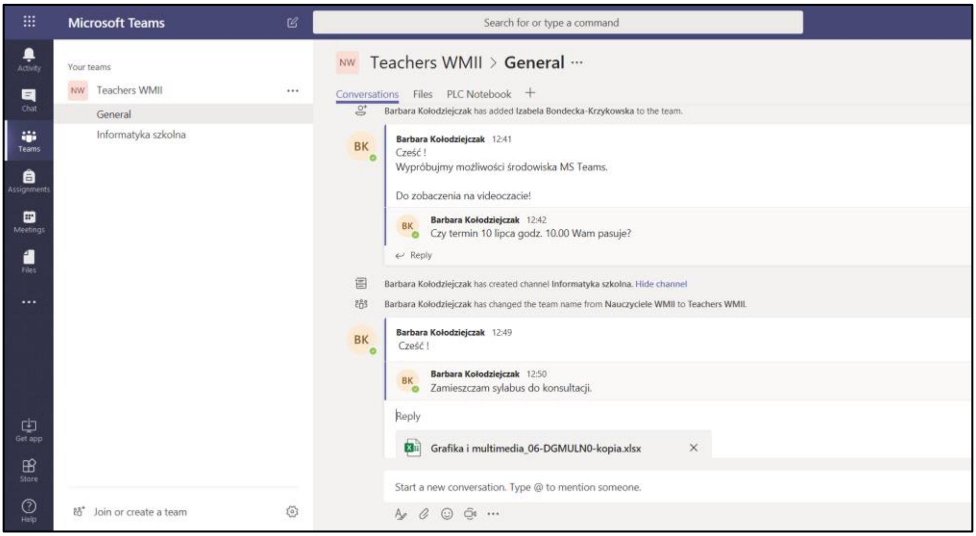

Figure 2. Classes in the Microsoft Teams environment
Source: Own work

The above-mentioned educational environments, although multifunctional and conducive to making creative and individualized learning conditions, have the undoubted disadvantage that they require higher competences from teachers and impose additional costs on the school for the development of an IT infrastructure, employing an administrator or paying for a license. It seems that these are barriers that will long prevent the implementation of these modern solutions into non-academic education. This is confirmed by the results of pilot studies conducted among school-teachers from the Wielkopolskie (Greater Poland) voivodeship and neighboring voivodeships.

2. THE CORE CURRICULUM AND MODERN TECHNOLOGIES

The core curriculum of general education in 2017 (Regulation of the Minister of National Education) clearly states: "The school should create conditions for students to acquire knowledge and skills needed to solve problems using methods and techniques derived from computer science, including logical and algorithmic thinking, programming, use of computer applications, searching for and using information from various sources, using a computer and basic digital devices, and applying these skills in activities from various subjects." (The core curriculum for primary schools , The core curriculum for secondary schools).

An important component of school education is the acquisition of social competences, such as communication and collaboration in a group, and the development of entrepreneurship and creativity skills in students through the participation and management of team or individual projects. For project implementation, information and communication technologies (ICT) should be used. The core curriculum also guarantees "...individual support for each student's development, according to their needs and capabilities." (The core curriculum for secondary schools)

The educational objectives included in the core curriculum impose on the school the obligation to create conditions for their implementation by providing an IT infrastructure and the obligation to upgrade the ICT competences of the teaching staff (Smyrnova-Trybulska 2018). Teacher training is carried out as part of postgraduate studies preparing for teaching a second subject and various types of projects financed by local governments and European Funds, such as the project of the city of Poznań "Uczeń z pasją" (A Student with Passion). During the studies, young teachers should be equipped with substantive knowledge and professional competences that will enable them to meet the requirements set by the new core curriculum.

Are teachers with many years of experience and those who are just starting their teaching career prepared to use the latest technologies? Do they have knowledge and competences to build and use educational environments conducive to developing pupils' independence and creativity and enabling individualized teaching? To what extent do the study programmes include the acquisition of such knowledge and competences? The author tried to find the answer to these questions by conducting pilot studies among active teachers and students of mathematics and computer science.

3. ANALYSIS OF RESEARCH RESULTS

3.1 Research goals

The overall goal of the research was to diagnose the use of portals and educational environments in school education.

The detailed objectives of the research among teachers included such aspects as:

– whether schools have educational or social portals or websites,
– for what purposes they are used by the school,
– whether, and to what extent, teachers use them and

– according to the respondents, which portals, educational environments, social networks or educational websites would be worth implementing in the school in which they work.

With regard to students of the teaching faculty, the research was aimed to:

– diagnose the level of knowledge and skills needed to use the portals or the educational environment in the work of a teacher and educator,

– examination of the opinion on the usefulness of these types of tools in school education,

– to examine opinions on the degree of time-consumption and level of IT knowledge necessary to use these tools, and

– indicating by them, tools or applications for which they would need to complete their education in order to be well prepared for the role of teacher and educator.

3.2 Participants

The questionnaires were filled in by 14 teachers of postgraduate studies of mathematics and computer science – the participants of the project “Uczeń z pasją”. They were experienced teachers of various specialties from primary schools, mainly in the Wielkopolskie and Lubuskie voivodeships. Their average working time in the teaching profession was 18 years (range: 4 – 36 years).

The second tested group was composed of second and third year undergraduate students of Mathematics and Computer Science at the Faculty of Mathematics and Computer Science (FMCS) of UAM. The survey was attended by 18 second-year students and 15 third-year students, of whom 6 have already taken a job as a teacher. Average work time in this group was 11 months (range: 3 months – 2 years).

3.3 Data collection and analysis

The survey was conducted using an anonymous survey consisting of multiple, single choice and open questions. The survey questions were divided into two parts: the first part was addressed to active teachers, the second to students. Students who had already taken a teaching job, filled in both parts.

The data were analyzed using the Fisher's Exact Test and Mann-Whitney U Test. Calculations were carried out at statistical significance α=0.05 in STATISTICA v.12.0 from StatSoft. Inc. (Tulsa, USA).

3.4 Analysis of results in the group of teachers

From the 20 schools whose teachers took part in the survey, 15 (75%) indicated the use of an internet application: 14 (70%) schools had their own website, and 10 (50%) had a profile on the Facebook social networking site.

None of the schools had its own educational portal or educational environment. The websites or profiles on the portal are used to promote the school and less frequently to communicate with parents and students. Only in 3 cases out of 15 were they also used for educational purposes. A detailed distribution of answers is presented in Table 1.

Table 1.

The manner of using the portal, social network service or school website.

For what purposes are the portal, social network, educational environment or website at your school used?	**Number of schools n=15**
for school promotion (news, galleries, school information, etc.)	15 (100%)
to communicate with students and parents	9 (60%)
to provide students with educational materials during the lesson	1 (7%)
to provide students with additional materials for independent work outside the classroom	2 (14%)
for testing students' knowledge	0 (0%)

Source: Own work

Only every third teacher often used the school's own website or profile on a social network. The others used it rarely or sporadically. Most often, teachers communicate with students and parents. Only every fifth teacher passed knowledge through this channel. A detailed breakdown of teachers' answers is given in Table 2.

Table 2.

The most common way teachers used the portal, social network site or school website.

Choose the most frequently used way of using the portal, social networking site, educational environment or website in your school.	**Number of teachers n=15**
I communicate with students and parents (organizational and educational matters)	9 (60%)
I use it to pass on knowledge during lessons	3 (20%)
It is used by the students outside the classroom to work independently (educational purpose)	3 (20%)

I use it to check students' knowledge	0 (0%)
I lead a special interest group	3 (20%)
I add photo reports, reports on outings and school trips	3 (20%)

Source: Own work

Three out of five teachers whose schools did not have any of the mentioned internet applications, indicated that it would be worth having a Moodle educational portal at school to pass on knowledge during the lesson, for the student's independent work outside the lesson, to test the students and conduct special interest groups. One of the teachers thought these types of applications such as Internet portals, services and websites are unnecessary in school education.

3.5 Analysis of results in the group of students

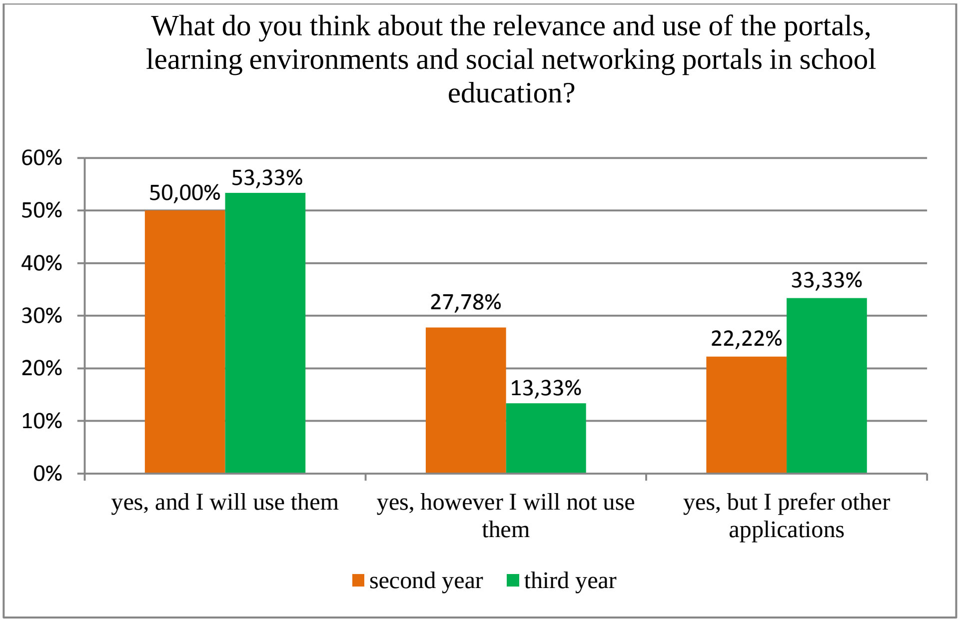

Figure 3. Distribution of answers to the question about the relevance and use of the portals, learning environments and social networking portals in school education

Source: Own work

Most students declared they were familiar with open-source educational portals such as Moodle (21 out of 33) and Online Learning And Training (31 out of 33), because at FMCS they are used by lecturers to support classes. On the other hand, their knowledge of educational environments such as Google Classroom (4 students) or Microsoft Teams (3 students) was minimal. The students strongly agreed regarding the usefulness of portals, educational environments and the use of social networking portals in education (100%), and there was no significant difference between students of the second and third years of studies (p = 0.593, Fisher's Exact test). However, only half of the students declared that they would use them in practice. The distribution of answers to the question is illustrated in Figure 3.

Students asked about the time-consumption and the level of IT competences necessary to use the portals and educational environments stated that it is time-consuming, however it brings a lot of satisfaction to the teacher and students (55%) and does not require high IT competences. It should be remembered that this is the opinion of students who have IT preparation to the extent necessary to teach computer science in primary school. Students in the third year have a higher awareness of the benefits of using educational environments (67% vs. 44%), but they also are aware of the increased amount of time and work needed to prepare materials for students (40% vs. 28%). However, no significant dependencies were found between the year of study and the answers provided. Detailed results are presented in Table 3.

Table 3.

Evaluation of time-consuming and level of IT competences necessary to use the websites and educational environments

The use of portals, educational environments and social networks in the educational process is:	Second year n=18	Third year n=15	p value*
simple and requires little time	3 (17%)	1 (7%)	0.607
simple and does not require extensive IT skills	10 (56%)	7 (47%)	0.732
time-consuming, but the benefits of use bring much satisfaction to students and the teacher	8 (44%)	10 (67%)	0.296
time-consuming to learn about the possibilities of the environment	6 (33%)	4 (27%)	0.722
time-consuming to prepare materials	5 (28%)	6 (40%)	0.488
necessary to have IT knowledge and skills that go beyond the capabilities of the average teacher	2 (11%)	2 (13%)	1

* Fisher's Exact Test

Source: Own work

One of the survey questions concerned the degree of preparation (on a scale of 1–5, where 1 meant "definitely not" and 5 "definitely yes") to use the possibilities of current technologies in the work of a mathematics and computer science teacher. The responses of students in both groups ranged from 2 to 5. Students of the third year were definitely more confident ($p=0.011$, Mann-Whitney U Test) confident in their preparation (Me=4, IQR=3–5) than students of the second year (Me=3, IQR=2–4). When asked which tools or applications they would use to expand their own education, students often mentioned the Moodle portal, the Google Classroom educational environment and the GeoGebra application.

3.6 Limitations

The research was conducted on a group of students and teachers in the academic year of 2018/19. In order to increase the representativeness of the results, the study should be continued in the following academic years by expanding the group of students to include student teachers of other specialties.

3.7 Discussion

In most primary and secondary schools there is still a lack of support for teaching through portals or environments dedicated to education. Schools often have internet websites or profiles on social networks and use them to promote the school and for the purpose of keeping in contact with parents. Teachers rarely use them, and if so, for organizational rather than educational purposes. Teachers' ICT competences are still at an average level, and their heavy workload is not conducive to self-education. Therefore, rather than portals or educational environments, ready-made materials offered by publishing houses, such as Gdańskie Wydawnictwo Oświatowe (https://gwo.pl/strony/2732/seo_link:dla-nauczyciela), Nowa Era (https://sklep.nowaera.pl/category/multimedia) or thematic websites (e.g. Megamatma, https://www.megamatma.pl/) are more popular. There are commercial companies on the Polish market that offer schools integrated education and educational environments, combining educational functions with the management of the institution (support of the school office, library, arranging timetables, printing school diplomas) and platforms with a built-in school register as well as tools for creating interactive assignments for pupils (Librus, Learnetic). They even compete with the free educational environments.

Students in the field of mathematics and computer science at the Faculty of Mathematics and Computer Science, Adam Mickiewicz University in Poznan were aware of and recognized the usefulness of educational and social portals, although only about half plan to use them in their professional work. Knowledge of learning environments like Google Classroom was rare. Only a few students were of the opinion that the use of portals and educational environments is difficult and requires knowledge and IT skills beyond the capabilities of the average teacher. The vast majority were aware that both the creation of materials and the use of portals and educational environments is time-consuming, although they can be satisfactory for both the student and teacher.

About 20% -30% of students declared that they prefer to use applications to quickly build educational materials and verify knowledge, such as the LearningApps, GeoGebra, Kahoot, Quizizz or Plickers. Research shows that the young generation of teachers of mathematics and computer science is not afraid to use new technologies and they select tools to minimize the time spent in the preparation of lessons. Therefore, that is why they do not always place importance on moving education into educational environments, which they consider to be time-consuming.

CONCLUSIONS

Subsequent reforms of education in Poland have changed not only the content, but also the methods of education, adjusting them to European standards and the changing technological possibilities. Goals posed by the current school core curriculum include raising students' social skills, developing their entrepreneurship and creativity and employing individualized teaching in order to adapt it to the needs and abilities of the individual students. This creates conditions for the implementation of educational environments at schools, which will efficiently support the implementation of these goals. On the basis of the pilot studies, it can be said that most primary schools do not currently have such an environment, and changes in this area must be preceded by raising teachers' ICT competence. It is also important to equip new generations of teachers with the knowledge and skills in freely selecting educational tools. Negligence in this area will exclude from the education process the possibilities offered by current technologies and consequently fall short of expectations of students who will seek knowledge and support on the Internet.

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TRAINING FOR FUTURE PRIMARY SCHOOL TEACHERS IN USING SERVICE H5P TEACHING MATHEMATICS

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Abstract: *The article is devoted to a research of the problem of the training for future primary school teachers in using information technology (IT) in teaching mathematics, in particular, in the aspect of the use of various online resources and online services for teachers. The necessity of using IT in mathematics lessons is substantiated based on peculiarities of the development of digital generation children's cognitive processes. The advantages and disadvantages of using services such as Learning Apps, Plickers and H5P to create interactive exercises, have been revealed. The results of IT introduction in the training for future primary school teachers were analyzed. The technology of teaching future primary school teachers to create interactive math exercises with the help of the online service H5P have been developed and implemented in the process of methodological training at the South Ukrainian National Pedagogical University named after K. Ushynsky and Izmail State University of Humanities.*

Keywords: information technologies, gadgets, digital generation, cognitive processes, training for future primary school teachers, interactive exercises, Learning Apps, Plickers та H5P.

INTRODUCTION

Given the high intensity of information flow and communication in the online environment, their impact on a child's mental development and personality formation cannot be underestimated. Every year, scientists are getting more and more information proving that infocommunication technologies not only complement and extend a child's life, but also affect the entire structure of their activity, both offline and online (Soldatova, G., 2018). The overuse of IT as a tool of daily living has led to a recent increase in the list of common skills that modern people should have. Today's updated list of key competences for lifelong learning includes digital competence (proposal for council recommendation on key competence for lifelong learning, 2019), which emphasizes confident, critical and responsible use and engagement with digital technologies for learning, professional activity and participation in the life of society. It is likely that with the development of the latestIT and their introduction into the public sphere of the country, the requirements for citizen's digital competence will increase. This is one of the most important reasons for reforming the elementary level of education, in particular, the use of modern IT by the teacher when teaching mathematics to primary school children.

1. PREREQUISITES OF USING INFORMATION TECHNOLOGIES IN MATHEMATICS LESSONS IN PRIMARY SCHOOL

1.1 The impact of IT on the development of the cognitive processes of primary school children – representatives of digital generation

Contemporary primary school children are representatives of digital generation called "digital native" or "net generation", they freely operate gadgets by finding the content on the Internet. However, scientists have not yet given an unambiguous answer to the question "Do gadgets have a positive or negative impact on a child's development?" Although, at the beginning of the 21st century, IT was considered as a barrier to children's mental development since the use of gadgets limits children's communication with peers and adults (Armstrong, Casement, 2000), their use is detrimental to children's health, in particular they influence the eyesight. Therefore, IT has a negative impact on the child's social, emotional, and physical development. It should be noted that these factors are still relevant, in particular the involvement of parents in the virtual environment further encourages them to involve children early in operating gadgets to watch miles of movies, to play games on the phone or tablet PC. Thus, modern children much less communicate with their parents, much less play with each other, being babies they already live in two worlds – real and virtual. Competing with the real world, the virtual world is increasingly attracted to the child with high levels of stimulation, a dynamic picture, and we have numerous examples when children even meeting each other do not want to interrupt their activity in the virtual environment. The culture of communication with adults and peers is gradually disappearing, and children are increasingly "communicating" with the gadget, which is essentially a communication on their own. Definitely, it is detrimental to the personal development of the child and to the formation of positive traits. Children do not have the tools to resolve conflicts with others, and they try to resolve all issues by force.

These problems have been still present, and scientists need to decide how to correct them, because it is obvious that the modern development of mankind is impossible without IT technologies. Therefore, scientists have tried to debunk the myth of IT as a barrier to cognitive development (Yelland, 2011), (Plowman, McPake, 2013), and find that the proper use of IT is a valid tool for improving child's development and is not a barrier to mental development. Angela M. Fish and colleagues have shown that children using home digital devices have a higher level of cognitive development than children without a computer at home (Fish, McCarrick, & Partridge, 2008). Gary Small and Gigi Vorgan emphasize that children who are attached to a computer have higher IQs and better cognitive abilities than their peers who do not use computers (Small, G., Vorgan G., 2008). Similar results were obtained by another group of researchers – Jackson, Witt, Games, etc., who have shown that children who use the Internet have higher academic performance than children who do not use the Internet (Jackson, Witt, Games, Fitzgerald, von Eye, Zhao, 2012).

So, today, there are two "camps": representatives of the former – those who believe that IT has a positive impact on the development of higher mental functions (e.g. Small and Vorgan) and use IT in educating primary school children, representatives of the second – those who for some reason do not use IT and believe that modern gadgets have a bad impact on children's development, such as Spitzer (Spitzer, 2014). However, the results of most studies demonstrate that the positive impact of digital technologies on the modern schoolchild prevails over the negative one.

The peculiarities of cognitive processes of digital children are the predominance of visual thinking, clip thinking, linguistic minimalism, rapid fatigue and loss of concentration, impaired auditory memory and overwhelming visual memory (Skvortsova, Britskan, 2019). The research by leading scientists DeBell and Chapman confirms the positive impact of digital technologies on the development of visual intelligence: the ability to simultaneously control multiple visual stimuli, visualization of spatial relationships (DeBell, Chapman, 2006), image recognition, development of visual memory (Van Deventer, White, 2002, White), metacognitive planning processes, search strategies and information appraisal (Tarpley, 2001).

According to scientists, technological development has directly affected the educational system in the way that the object of pedagogical influence is a new type of pupils, namely digital children. In fact, educational changes are driven by the striking gap between traditional teaching methods and the needs of the modern generation (Bennett, and Maton, 2010). Indeed, teachers of modern children are mostly non-digital generation members who are poorly aware of online services for creating educational and gaming content, or are unable to use modern gadgets in lessons. However, this situation has gradually improved with the arrival of young teachers – recent graduates of universities.

1.2 Diagnosing the state of future primary school teachers' readiness for the use of IT in mathematics lessons

The research and experimental work was carried out on the basis of South Ukrainian National Pedagogical University named after K. D. Ushynky and Izmail State University of Humanities. The pilot questionnaire covered 100 undergraduate students of specialty "Primary education".

In order to diagnose basic knowledge and the attitude of primary school teachers to the introduction of IT in mathematics lessons in primary school, we have developed a questionnaire with different types of questions. The questions of the elaborated questionnaire concerned both general data about the respondents and certain practical skills.

One of the questions asked students to rate their IT skills on a five-point scale. As a result of the questionnaire analysis, we found that all (100%) students own computers and have experience in using information technology in their educational activities. All students rated their IT skills as 5 points (100%); 100 students answered that they are able to work with email as 5 points (100%). Work with the file system was evaluated by 95 respondents as 5 points (95%), 5 students as 4 (5%). Work in a Microsoft Word text editor was rated by 92 students (92%) as 5 points, 8 students (8%) as 4 points. Regarding the ability to make presentations, we received the following distribution of students: 5 points – 88 learners (88%), 4 points –10 (10%), 3 points – 2 (2%). According to the development of the ability to process graphic image, we obtained the following data: 5 points – 90 students (90%), 4 – 6 students (6%), 3 – 4 (4%); ability to calculate using electronic spreadsheets: 5 points – 74 students (74%), 4 – 12 (12%), 3 – 14 (14%); ability to install necessary software: 5 points – 25 students (25%), 4 – 45 (45%), 3 – 28 (28%), 2 – 2 (2%); blogging skills: 5 points – 50 students (50%), 4 – 30 (30%), 3 – 17 (17%), 2 – 3 (3%). Students' self-assessment of their ability to work in professional online networks was rated as follows: 5 points – 20 students (20%), 4 – 36 (36%), 3 – 27 (27%), 2 – 10 (10%) and 1 – 7 (7 %); the ability to create websites was rated as 5 points by 12 students (12%), 4 – 10 (10%), 3 – 65 (65%), 2 – 3 (3%) and as 1 point – 10 (10%). The results of the study are presented in Figure 1. Analyzing the answers to this questionnaire, we can conclude that the students have basic knowledge and IT skills gained during their schooling and higher education.

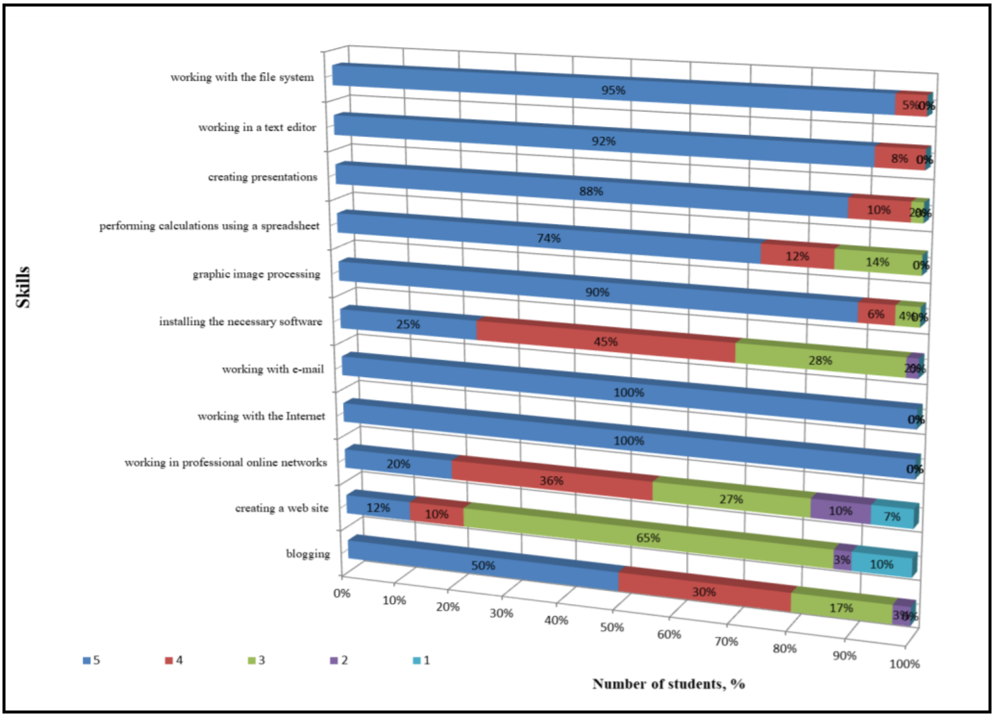

Figure. 1. Students' self-assessing of the level of IT proficiency
Source: own work

Comparing the studies of 2018 (Skvortsova, Britskan) and 2019 (Table 1), we can conclude that in 2019 students had more profound knowledge and more practical IT skills. We can justify this phenomenon by the fact that the younger the researcher, the more experience in IT he has.

It should be noted that prior to the experiment, students had experience of using multimedia presentations at lectures on "Methods of teaching mathematics", used information from web-pages, social networks, etc., in order to master this discipline.

At the beginning of the experiment, students were asked to answer an open-ended question, "What publicly accessible Web resources do you use?" in order to determine which IT tools they consider appropriate in primary school mathematics teaching. Future teachers have listed the following resources: https://skvor.info/, https://www.youtube.com, http://ru.osvita.ua/, https://learningapps.org/ etc. Unfortunately, this list is limited enough for the professional activity of a modern specialist.

The next question was aimed at future teachers' understanding of the necessity to use IT in teaching modern primary school children. Thus, 100% of students think it is necessary to use educational games, 97% – multimedia presentations, 98% – interactive exercises, 85% – educational videos and audio recordings, 83% – educational programs, 75% – tests and quizzes. Also, 100% of students agree that it is appropriate to use gadgets in teaching mathematics to primary school children. Therefore, most students agree that it is necessary to introduce IT in the education of modern children.

100% of the respondents answered to the question “Do you have experience in the H5P service?” “no”, but all of them expressed their willingness to participate in interactive exercises using the H5P service.

Thus, the results of our study show that students have basic knowledge, abilities and skills of using IT and willingness to improve them, in particular, to learn how to create interactive exercises using the H5P service.

Table 1.

Comparative characteristics of 2018 and 2019 students’ self-assessment of IT proficiency levels

	5 points			4 points			3 points			2 points			1 point		
	2018	2019		2018	2019		2018	2019		2018	2019		2018	2019	
blogging	5%	50%	+45	20%	30%	+10	46%	17%	-29	25%	3%	-22	4%	0%	-4
creating a web site	2%	12%	+10	8%	10%	+2	48%	65%	+17	17%	3%	-14	25%	10%	-15
working in professional online networks	4%	20%	+16	26%	36%	+10	37%	27%	-10	20%	10%	-10	13%	7%	-6
working with the Internet	100%	100%	0	0%	0%	0	0%	0%	0	0%	0%	0	0%	0%	0
working with e-mail	98%	100%	+2	2%	0%	-2	0%	0%	0	0%	0%	0	0%	0%	0
installing the necessary software	10%	25%	+15	32%	45%	+13	45%	28%	-17	13%	2%	-11	0%	0%	0
graphic image processing	22%	90%	+68	48%	6%	-42	28%	4%	-24	2%	0%	-2	0%	0%	0
performing calculations using a spreadsheet	21%	74%	+53	40%	12%	-28	39%	14%	-25	0%	0%	0	0%	0%	0
creating presentations	50%	88%	+38	49%	10%	-39	1%	2%	+1	0%	0%	0	0%	0%	0
working in a text editor	77%	92%	+15	22%	8%	-14	1%	0%	-1	0%	0%	0	0%	0%	0
working with the file system	70%	95%	+25	23%	5%	-18	7%	0%	-7	0%	0%	0	0%	0%	0

Source: own work

2. TRAINING FUTURE PRIMARY SCHOOL TEACHERS FOR USING INFORMATION TECHNOLOGIES IN MATHEMATICS LESSONS

2.1 The problem of selecting online services for creating interactive math exercises for primary school children: setting the criteria

Any teacher understands that it is impossible to give a modern lesson without using IT. But today there is another problem – the problem of choosing online services to create interactive exercises. It is well-known that there are now a small number of different services for teachers that offer different designs for creating tasks and their own bank of interactive exercises. What should a teacher do?

First of all, a highly qualified specialist should be aware of the new developments in IT that can be implemented in the educational process. We should note that there is no universal service that can be used for a long time. Since modern children are rapidly losing interest in certain tasks created on one service, the teacher needs to use the tasks created on different services and their combination to activate learners' cognitive interest.

Based on the study of the features of some services, we can assure that no matter how many opportunities and functions a certain service has, not all the tasks of the elementary mathematics teacher's educational set can be displayed on online services. Most teachers solve this problem by modifying the task to a specific service platform. Or vice versa, when one task from a textbook can be accomplished using different platforms.

In view of this, there is a need to set requirements for the selection of online services with the help of which you can create interactive exercises in mathematics, control and monitor the process of mastering a particular provision of the program. Having studied the features of the work of Web 2.0 services: Learning Apps, Plickers and H5P, we distunguished three groups of requirements: 1 – requirements for creating interactive exercises; II – requirements for controlling over their performance and monitoring pupils' performance; III – requirements for organizing work with the class (Skvortsova, Britskan, 2019).

The first group includes: 1) the opportunity to create exercises in all sections of elementary mathematics. Learning Apps and H5P allow the teacher to work with all sections of the elementary mathematics course – enumerating non-negative integers and regular proper fractions, arithmetic operations of addition, subtraction, multiplication and division with integers, quantities, plot-based mathematic tasks as well as algebraic and geometric propedeutics. Plickers somewhat restrict the teacher, but allows him to work with arithmetics. 2) the availability of sufficient number of platforms for a variety of interactive exercises. Learning Apps includes 17 platforms and 5 tools; Plickers service offers only 2 task designs; H5P allows the teacher to create interactive content for 42 different designs. 3) the possibility of vivid design of interactive exercises by using pictures, graphs, diagrams, audio and video materials, etc. Learning Apps and H5P allow the teacher to use texts, a variety of images, audio and video. Plickers can use text material and images. 4) the presence of animations, dynamism and special effects in interactive exercises. Learning Apps and H5P have a high level of dynamism and special effects when creating interactive exercises, and Plickers allows the teacher to use GIFs. 5) the ability to create differentiated exercises by difficulty levels. We can say that all the three services allow the teacher to create differentiated exercises by difficulty level, but exercises created with Learning Apps and H5P may be more diverse and not similar, and exercises created on Plickers may be different in complexity, but will look typically, since it has a limited number of platforms. 6) the opportunity to give a series of interactive exercises according to the level of progress, where the pupil sees how many exercises he needs to perform in order to move to the level above. With all the three services, the teacher can create a series of interactive exercises. 7) a clear and simple algorithm for performing interactive exercises. Analyzing the algorithms for creating interactive exercises on the three services, we can say that each service offers its own unique algorithm, which is different from other services. In our opinion, it takes less time to learn the Learning Apps algorithm, despite the fact that it has more platforms. The advantage of this service for teachers of Ukraine is that it is translated into Ukrainian. And Plickers and H5P services are in English. The algorithm for creating interactive exercises on the Plickers service is comparatively easier than on the H5P service. This can be explained by the number of platforms. But it should be noted that the Plickers service has a specific algorithm for live broadcasting, which also needs to be mastered by the teacher.

The second group of requirements is connected with the third group of requirements, namely: 1) the ability to create a virtual class: a selection of exercises or series of exercises to the specified lesson and the corresponding class. Learning Apps and Plickers allow the teacher to work with a virtual class. 2) availability of a bank of interactive exercises that can be used at any time without creating your bank. Learning Apps and H5P contain their own interactive content that can be used in one’s concrete activity. But Learning Apps allows any exercise in the collection to be customized. Unfortunately, it does not have this function. Plickers does not have its own collection of exercises. 3) an opportunity to use interactive exercises offline. This benefit is provided to the teachers who work on Learning Apps. 4) the teacher’s ability to further work with the results. Learning Apps and Plickers’ users can work with the assessment results.

Therefore, the H5P service meets most of the requirements for selecting online services that can be used to create interactive math exercises, to control and monitor pupils’ learning process as it has many advantages over other online services.

2.2 Theoretical and practical principles of creating interactive math exercises using the online H5P service

One of the ways of integrating IT in teaching mathematics to primary school children is to use the Web 2.0 free resources for the teacher: wikis (websites), social networks, podcasts, and virtual worlds. The scholar Howe J. distinguishes four types of processes in Web 2.0: 1. sharing user-provided content; 2. the evolution of community-developed tags and organization schemes for a large set of user-generated content; 3. elaboration of content collections by the users' community; 4. object search, trends, and app reviews (Howe, 2006). We emphasize that Web 2.0 enables teachers not only to create their own educational and game content, but also to share it on the Internet, as well as to enjoy the achievements of their colleagues. Let us consider the H5P service in details.

H5P is a plugin for existing editing systems that allows the system to create interactive content: interactive videos, presentations, games, quizzes, flash cards, posters, collages, charts etc. H5P is an English language service, so users need to be fluent in English or work with a Google Chrome browser that offers instant webpage translation to create tasks.

To create H5P interactive content, the user must follow the steps below: visit https://h5p.org, create a free account and connect their account to their email in case of password recovery. Having logged on, the user immediately finds the menu of the site – a list of hyperlinks to its sections: Examples & downloads, Documentation, Goals & roadmap, Forum, My account. To see and view the tasks created with H5P, you should choose Examples & downloads, where the user immediately finds the types of content that he or she can work with. H5P offers users the following content types: Accordion, Agamotto, Arithmetic Quiz, Audio Recorder, Chart, Collage, Column, Dialogs Cards, Dictation, Documentation Tool, Drag and Drop, Drag the Words, Essay, Fill in the Blanks, Find Multiple Hotspots , Find Hotspot, Flashcards, Guess the Answer, Iframe Embedder, Image Hotspots, Image Juxtaposition, Image Pairing, Image Sequencing, Image Slider, Impressive Presentation, Mark the Words, Memory Game, Multiple Choice, Personality Quiz, Questionnaire, Quiz (Question Set), Single Choice Set, Speake the Words, Speake the Words Set, Summary, Timeline, True / False Question, Virtual Tour, Interactive Video, Course Presentation, Branching Scenario, Advanced fill the blanks. Selecting the type of content you want, you can look at specific tasks.

Accordion Content provides an opportunity to display the learning material as a plan to follow. This platform will be useful for those teaching mathematics to primary school children, as digital children are known to better perceive new material through visual channels of perception. And as Rickers emphasized, it is advisable to present educational information in graphic and, if possible, electronic forms. For example, in form 2, we can offer the following scheme for consolidating pupils' knowledge of units of measurement (Figure 2).

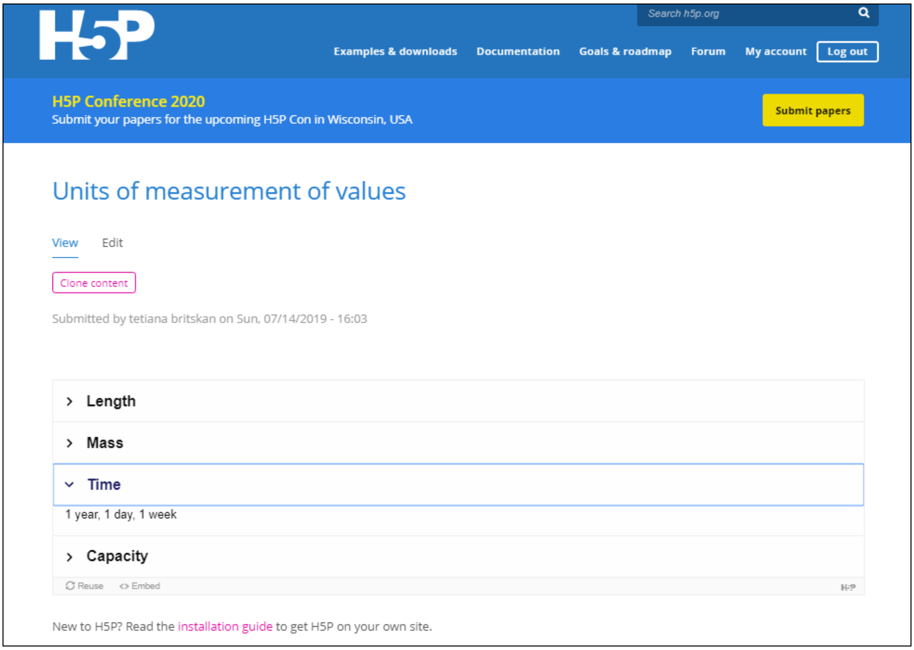

Figure. 2. Task created with help of Accordion Content
Source: own work based on https://h5p.org service

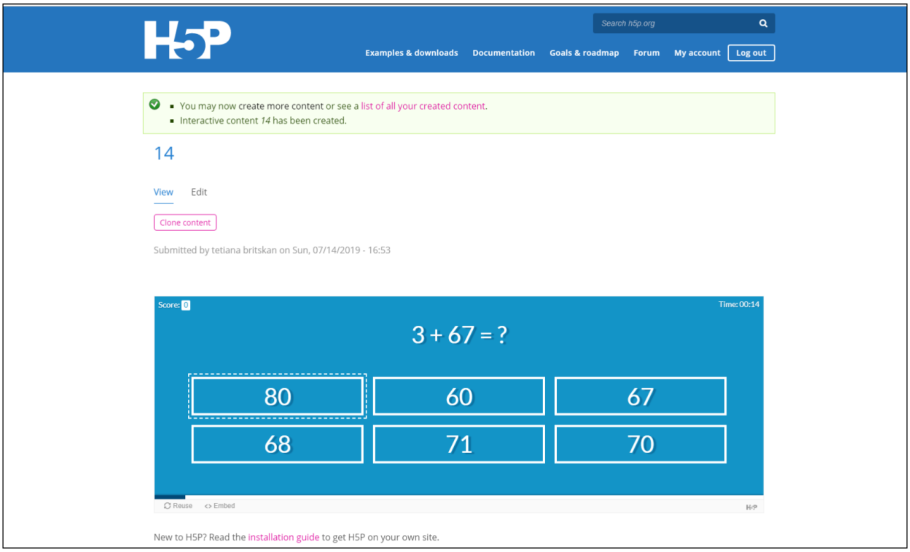

Figure. 3. Arithmetic Quiz
Source: own work based on https://h5p.org service

Agamotto Content allows the teacher to create a series of interactive images for analyzing and learning the sequence. Explanatory material can also be written to each image.

The H5P service independently creates arithmetic quizzes within the first hundred, the teacher only needs to choose the number of indices (max – 20) and arithmetic actions (addition, subtraction, multiplication and division) (Figure 3). This is very convenient, but the service does not take into account the following features: we work with numbers (single digits, double digits), with / without crossing the decades, table or extra-table cases. In our opinion, it is advisable to use Arithmetic Quiz to consolidate computing skills.

The H5P service enables the teacher to create interactive videos that make primary school children get interested to study. To do this, the teacher may upload his video or link to the video. The next step is to create an interactive task at any time interval of the video. To do this, one should select the function "add interactivity" and from the list of known platforms select the necessary one. For example, to illustrate the situation of a maths problem, we found a video about the main character of the task, raccoon, and the way he eats cherries (Figure 4). Primary school children are happy to watch the main character, and then they will need to solve and enter the answer in the box. If the pupil gave the correct answer to the question, then he can move on to the following tasks. We should note that within the same video, many interactive exercises of different types can be created, which will not allow pupils to get used to the tasks of only one type.

While performing interactive tasks, H5P monitors their correctness and captures both intermediate and final points.

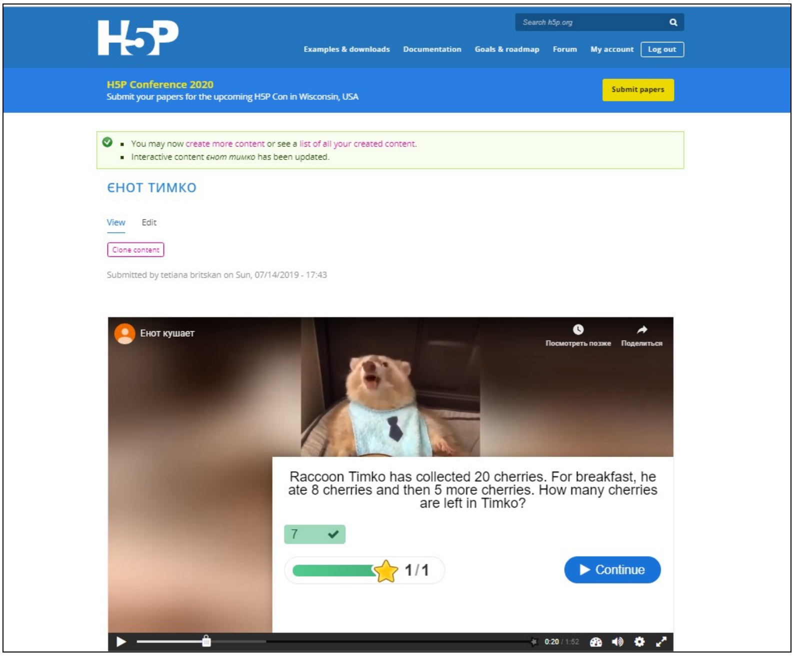

Figure. 4. Interactive Video

Source: own work based on https://h5p.org service

We should note that H5P users can create interactive content for WordPress, Moodle, or Drupal by adding the H5P plugin, or integrate it via LTI with Canvas, Brightspace, Blackboard, and many other VLEs that support LTI integration.

2.2 Approaches to teaching future primary school teachers to create interactive content with H5P

The purpose of the pilot study is training future primary school teachers to create interactive mathematics content using H5P.2.2.

The experimental study was conducted at the Universities of Ukraine – South Ukrainian National Pedagogical University named after K. D. Ushynsky and Izmail State University of Humanities over one academic year. The experiment was attended by students of the 1-3 years, specialty 013 “Primary education”. The experimental study was carried out within the course ‘Methods of teaching mathematics” at the expense of hours allotted for independent (self-guided) work – 72 hours. Altogether, 100 students participated in the study, 50 of them were in the experimental group (Izmail State University of Humanities) and 50 students were in the control group (South Ukrainian National Pedagogical University named after K. D. Ushynsky).

The students of the experimental group were specifically trained to work with the H5P service to use it when preparing tasks for primary school children. The students of the control group had to independently study the possibilities of the service and to formulate tasks for the pupils.

In the experimental group, training to work with the service for creating interactive content included several stages.

In the first stage of the study, students of the specialty 013 "Primary Education" were shown ready-made interactive content created on this service. The purpose of this phase was future teachers'mastering of the work with the content in the role of users and evaluating the performance of tasks by other students of their own group.

It should be noted that when studying the questions from the course "Methods of teaching mathematics in primary school", the attention was paid to how different educational materials can be presented in the form of interactive content. Therefore, while performing the tasks, students paid attention to such methodological aspects as: 1) the topic of the mathematics course which the task was created for; 2) the purpose of the task – the achievement of which program results the task is aimed at; 3) what stage of the learning cognition organization the task can be used at (consolidation of basic knowledge, obtaining new knowledge or learning a new mode of action, formation of abilities or skills, control and evaluation of learning outcomes); 4) opportunities to improve the task.

Thus, in the first stage, students gained experience in both the role of the task performer and the situation of observing the work of other performers and analyzing the completed tasks from a methodological point of view.

The second stage of the study involved acquainting prospective teachers with the H5P service and the algorithm of working with it. In order to learn the possibilities of this service, some lectures for the students of the experimental group were read on the topics: "Possibilities of the H5P service" and "Creating interactive mathematics content for primary school children using H5P". It should be noted that the creation of interactive content in mathematics has its own peculiarities, in particular the formulation of interactive tasks and their answers. For example, it is advisable to select Drag and Drop, Fill in the Blanks, Image Sequencing, Image Juxtaposition platforms to create interactive tasks on the topic of enumerating non-negative integers and regular proper fractions; arithmetic material and values – True / False, Quiz, Fill in the Blanks, Accordion; plot-based mathematical problems – Interactive Video, Course Presentation, Drag the words; algebraic and geometric propedeutics – Image Juxtaposition, True / False, Quiz, Fill in the Blanks.

In view of the above said, we have developed an algorithm for creating interactive content using H5P: 1) selecting a task from a textbook or tutorial; 2) developing a methodology of work on the task in accordance with the studied methodological approaches; 3) choosing a suitable platform that provides a convenient task interface for pupils; 4) designing possible actions when completing the task; 5) developing an algorithm of the pupils' actions to accomplish the task; 6) drawing up instructions for pupils; 6) preparing instructions for pupils stating the form of control and time limits.

The aim of the third stage of the experimental work was to teach students to create interactive content. At lectures, practical and laboratory classes in the course of “Methods of teaching mathematics” students under the guidance of the teacher obtained methodical knowledge and skills, and during consultations for independent (self-guided) work – acquired the ability to create interactive content.

We should note that most students learned how to create interactive content using the H5P service, but many difficulties arose when working with the H5P English service.

In the fourth stage, students had to apply the obtained knowledge, abilities and skills of work with the H5P service while creating their own interactive mathematics content for 1-4 form pupils according to the workbooks by S. O. Skvortsova and O. V. Onopriienko (Skvortsova, Onopriienko, 2017).

To create interactive content in mathematics, topics of 1st and 2nd forms were offered, namely, “Subtracting digits of the second set of five”, “We measure masses of objects”, “Enumerating numbers of the first hundred”, “Problems of finding numbers by the sum of two numbers” etc. The created interactive tasks focused on the stages of learning cognition, such as the stage of skills’ formation and the stage of testing the formation of certain knowledge, ability or skill (Figure 5, 6).

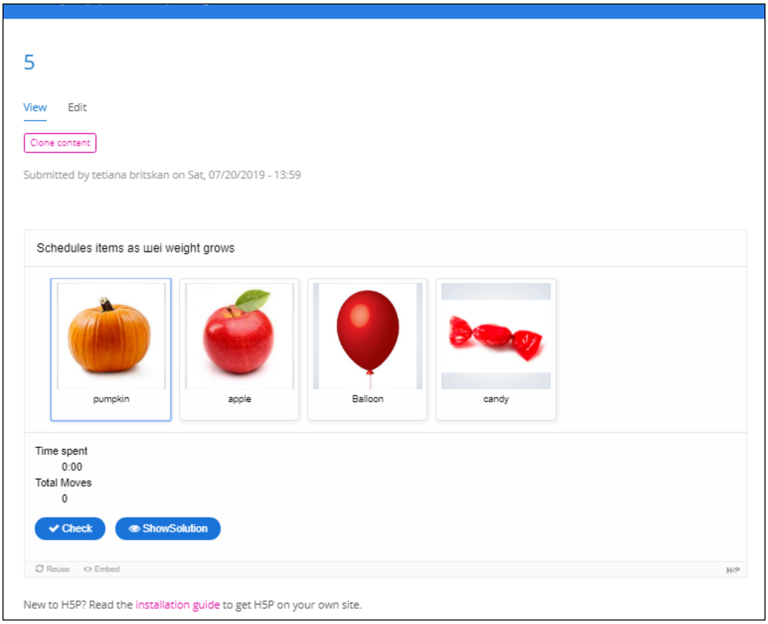

Figure 5. Interactive exercise of the student

Source: own work based on https://h5p.org service

Students' individual projects were assessed according to the following criteria: methodological, technical and aesthetic. Indicators of the methodological criterion were the correctness of the methodological development of the task, the completeness of adherence to the indicative basis of the action, the clarity of the task instructions for children, technological efficiency to perform actions with the elements of the task. The technical criterion was characterized by the following indicators: optimality of the choice of platform opportunities for accomplishing the task, correctness of the settings, dynamism. Indicators of the aesthetic criterion were: external attractiveness (brightness, funny character and modernity of the pictures, location on the plane of the task elements), adherence to the color scheme which causes positive emotions in children.

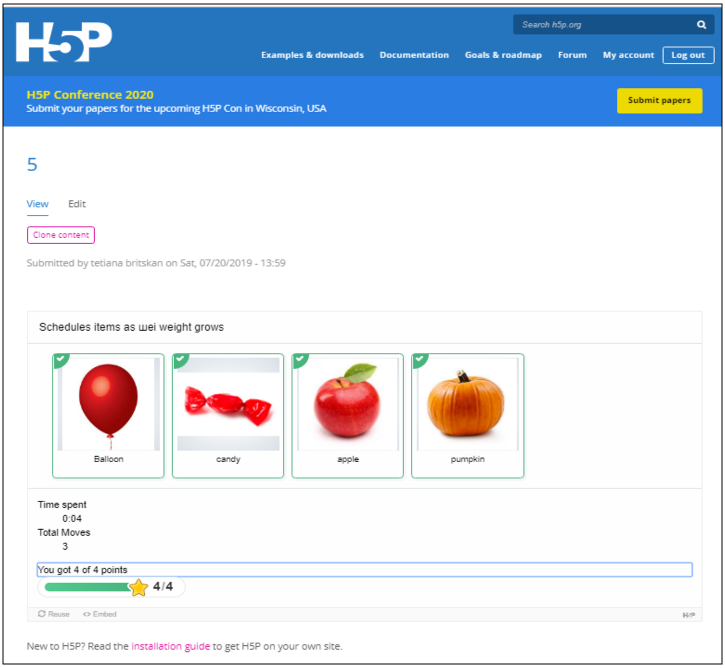

Figure 6. Interactive exercise creating with Image Sequencing
Source: own work based on https://h5p.org service

Identification of these indicators by methodological and technical criteria made it possible to characterize the levels of developing interactive content using H5P:

– low: fragmented knowledge and ability to create interactive tasks; the student can organize pupils' work on the service based on the ready-made interactive content, but has difficulties in controlling the progress of solving the interactive tasks and assessing pupils' learning achievements.

- medium: a student has some theoretical knowledge of the service and is able to create his own model exercise, but has difficulties in editing the service when creating his own interactive content.
- sufficient: the user knows the features of the service and is able to create standard tasks using images and has the knowledge and skills to adjust the service for pupils' work and assess their results.
- high level: students' knowledge is deep, solid and systemic; the student is able to create interactive content and edit their own tasks according to their needs, organize pupils' work with a series of learning tasks and can further assess pupils' educational achievements.

In the course of the pilot study, we used some elements of peer assessment, where students not only become observers of teacher's assessment of the results, but are involved in the use and development of the assessment criteria, in self-assessment and peer assessment, in reflection on their own learning progress, and in tracking their performance, as well as in the feedback analysis to make further changes to the learning process for improving their knowledge, skills and behavior (Morze, Vember, 2019).

Based on the assessment of individual projects completed by future primary school teachers, it can be stated that the vast majority of students (83%) have mastered the method of creating interactive content using the H5P service. 17% of the future teachers have acquired only the ability to use the H5P service to find ready-made interactive content. These results can be explained by the fact that H5P is quite difficult to operate because the service is in English. But if more time is spent exploring the features of this service in details, H5P will become a major help in the preparation of interactive content for teaching mathematics to primary school children.

CONCLUSION

Nowadays, giving mathematics lessons in primary school is impossible without the use of IT including online services. One of the services that allows teachers to create interactive content is H5P, useful for every teacher.

In the course of the experimental work the state of students' readiness for the use of IT in mathematics lessons in primary school was investigated and a comparative analysis of the results of years 2018 and 2019 was conducted. The students proved to have basic knowledge of IT, IT skills and abilities, and 100% of them demonstrated willingness to improve these skills, in particular, to learn how to create interactive content with H5P.

We have developed a technology for teaching students to create interactive content using H5P. As a result of the experimental learning, 83% of prospective primary school teachers have mastered the ability to create interactive mathematics content using H5P.

We see further research prospects in creating interactive mathematics content for primary school children; acquainting primary school teachers and students of the specialty 013 “Primary education” with other online resources and online mathematics services, such as Moodle, Google Forms, Webanketa, Online Test Pad, GoConqr, PlayBuzz, Baamboozle, Kahoot!, Triventy, Socrative, Quizalize, ProProfs, Purpose Games, Flippitty etc.

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MODELS OF E-LEARNING SYSTEMS ARCHITECTURE USING AI COMPONENTS

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Abstract: *The aim of the study is to present the current state of research on the models of e-learning systems architecture designed using Artificial Intelligence (AI) components. To achieve this goal, the literature of the subject selected from the databases: LISA, LISTA and ERIC and other internet sources were researched. The test results are presented in the following order: (1) Introduction. (2) Basic concepts. (3) Models of e-learning systems architecture. (4) Architecture of e-learning systems with AI elements. (5) Conclusions are presented at the end of the article.*

Keywords: Artificial Intelligence, Intelligent Tutoring Systems, Learning Technology Systems Architecture.

INTRODUCTION

Intelligent Tutoring Systems (ITS) are the subject of research, often conducted from the point of view of their application and usefulness in modern learning concepts. This is evidenced by numerous studies and reviews of literature on this subject. The latest developments include work: (Soofi, Uddin 2019), (Mousavinasab, Zarifsanaiey, Kalhori, Rakhshan, Keikha, Saeedi 2018), (Alkhatlan, Kalita 2018), (Dašić, Dašić, Crvenković, Šerifi 2016), (Sharma, Ghorpade, Sahni, Saluja 2014), (Santhi, Priya, Nandhini 2013), (VanLehn 2011), (Graesser, VanLehn, Rosé, Jordan, Harter 2001), (Nwana 1990).

The reference model for Learning Technology Systems Architecture (LTSA) was developed by the Institute of Electrical and Electronics Engineers (IEEE) and published in the document (IEEE Std 1484.1-2003). LTSA proposes a conceptual architecture that facilitates the educational process using information technologies. According to LTSA, it is possible to identify processes such as:

Learner, Evaluation, System Coach and Delivery in the teaching system, which are units implementing educational processes. In addition, an important element of the system is the database storing historical data on student performance in the teaching/learning process (Records Database), as well as the repository for storing learning resources supporting the learning process (Learning Resources Repositories). The extension of this concept is a model called "Framework to Heritage Education" (Mendozaab, Baldirisab, Fabregat, 2015).

Models of architecture of e-learning systems are also the subject of research. Issues such as the architecture of learning technology systems, common structures in Learning and Teaching Services (LTS) and solutions for specific systems such as knowledge-based, distributed or adaptive e-learning applications are being addressed. In the literature of the subject, we can find, among others works: (Pattnayak, Pattnaik, Dash, 2017), (Armenski, Gusev, 2008), (Pahl, 2008), (Hoppe, Verdejo, Kay, 2003).

In the article, after explaining the necessary concepts, we will review contemporary models of e-learning systems architectures and present examples of e-learning systems architectures with AI components.

Artificial Intelligence is defined differently. Four AI approaches have been proposed in discipline research: Acting Humanly (the Turing Test approach), Thinking Humanly (the cognitive modeling approach). Thinking Rationally (the *laws of thought* approach), Acting Rationally (the rational agent approach) (Russell, Norvig, 2016, p. 2). In each approach, different definitions are formulated, e.g. in the Thinking Humanly category we can use the definition: AI is *[the automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...* (Bellman, 1978, p. 3).

Depending on the definition, the AI may contain various components/ elements. The main research topics in AI include: automated reasoning, cognitive science (which connects computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind), computer vision, knowledge representation, logic-based reasoning, machine learning, natural language processing, neural network, rational agents, robotics (Flasiński, 2016) (Russell, Norvig, 2016). It should be remembered that a number of disciplines form the basis of AI. These are Computer engineering, Control theory and cybernetics, Economics, Linguistics, Mathematics, Neuroscience, Philosophy, Psychology (Russell, Norvig, 2016). We will begin our considerations with the definition of the concept of the model of architecture of e-learning systems, which use AI elements.

1. BASIC DEFINITIONS AND CONCEPTS

1.1 Definition of the concept of the model

We will start our considerations with the definition of the model. This is an ambiguous concept. The model can be an abstract representation of the existing reality or reality that will be created. The model may refer to both material and non-material entities (Wolski, 2019). The model also means a certain pattern or a broadly understood way of acting (Findeisen, 1985, p. 339). The model understood in this way is often combined with the system. The system model means *presenting the important properties of the real (or created) system that we are interested in in a form convenient to us* (Findeisen, 1985, p. 339) and is usually a simplification of reality. There are conceptual or qualitative, physical, computer, mathematical models (Findeisen, 1985, p. 339).

As already mentioned, the concept of the model is ambiguous and has different meanings depending on the discipline. In IT projects, precisely in requirements engineering, the model represents the reality that interests us. Creating a model is cognitive and/or descriptive and in order for it to be possible, the model must reduce the given reality and present it at a certain level of abstraction. Each model is created for a specific purpose and in a specific context. The ideal model contains only information that is relevant from a particular perspective. When creating a model that will be understandable for its author and recipient, it is necessary to use the same language/notation. Modelling language is defined by: (1) syntax - which defines what elements can be used in this language and defines possible combinations of these elements, (2) semantics - which defines the meaning of individual elements and their linking, which allows for correct interpretation of models created in help of this language. The most commonly used language for modelling requirements is UML (Wolski, 2019).

In the field of requirements engineering, the needs of stakeholders are realized, which can be treated as goals to be achieved by the system being created. Goals can be documented using natural language as well as using goal models. Two types of AND/OR relationships/ compositions can be used to model such goals. The relationship/composition hierarchy can be modelled using a tree. In the case of an AND relationship, all sub-goals must be met to satisfy the parent goal. On the other hand, in the case of an OR relationship, it is enough to fulfil only one sub goal to fulfil the superior goal (Wolski, 2019).

In system analysis, we use the term model system, which should externally behave like a system, although it may have a different internal structure. The system model performs such tasks as: (1) describing the communication model and connections between system elements; (2) illustration of the course of all processes from the point of view of clients, specialists and users; (3) verification of facts in terms of completeness of consistency and correctness

(Plebaniak, 2013). In addition, the following are distinguished: experimental model, statistical model, context model, case comparison model, process stage model, negative case analysis model (Lofland, Snow, Anderson, Lofland, 2009, p. 222-223).

System analysis for modelling the system uses graphical tools or diagrams. At the stage of system analysis, it is important to develop: (1) a logical model of the designed information system, (2) a physical model of the system. A logical model is a set of information defining the behaviour of the system. The physical model is a proposal of a specific implementation of the logical model, i.e. a technical project of software and hardware solutions (Gryglewicz-Kacerka, Duraj, 2013).

In computer science we use the Database Physical Model. It is a model of reality slice expressed by means of classes, tables, files and structures enabling access to data. The physical model of the database contains all the detailed information about the organization of data in the database (tables, files, physical organization of sets) and is a mapping of the logical model of the designed and analysed system. The physical model is a concrete implementation of the logical model based on the selected data model (hierarchical, network, relational, object) (Gryglewicz-Kacerka, Duraj, 2013, p. 10).

Information systems use a system model that includes, among others, object class definitions, a database schema, and a description of the graphical user interface. These definitions are usually available in the basic information dictionary via a dedicated component, specifically for this purpose, e.g. system model server (Kołodziński, Betliński, 2007). The traditional model of the system life cycle is also analysed and modified (requirements analysis, design, coding, testing, installation, operation, withdrawal). These modifications result from the striving to adapt to the objectives and assumptions of a given, specific system or organization. Tadeusiewicz mentions: a cascade model, the model of Fry, a prototype model, a spiral model (Tadeusiewicz, 2019).

1.2 The concept of system architecture

System architecture is most often created for information and information systems. We are talking about IT system architecture, software architecture, application architecture, intelligent system architecture, service-oriented architecture (SOA).

In general, we can say that architecture is a high-level system presentation that can serve as a basis for discussion among various participants. System architecture is a compact and easy to learn description of system organization and cooperation of its components. It is a small, intelligible model of the structure of the system and the way in which its elements interact. Architecture can be passed on to other systems that have similar requirements. It can be represented using graphical system models (Sommerville, 2000).

The architecture of most large systems does not correspond to any chosen style, but there are architectural models specific to concrete fields of application. Such system architectures vary in detail, but you can repeatedly use a common architectural structure to build new systems. Such architectural models are called architectures characteristic of the field. There are two types of architectural models: general models and reference models.

General architectural models reflect the architecture of existing systems. Reference models are, however, the results of research in the field of application. They represent idealized architectures that include all the facilities that the system could offer. Reference architectures can serve as the basis for system implementation (Sommerville, 2000).

Large systems rarely correspond to one architectural model. They are diverse and include various models on various levels of abstraction. The models of the system division are, among others repository model, client-server model and abstract machine model. The repository is a model for sharing data in a shared store. In client-server models, data is usually dispersed. In layered models, each layer is implemented using the features of its base layer (Sommerville, 2000).

After designing the structural architecture of the system, the next step in the architectural design process is the division of subsystems into modules. There is no precise way to divide the system into modules. There are two models of sub-system division into modules: the object model and the data flow model. The object model divides the system into a set of communicating objects. The data flow model divides the system into functional modules that download input data and process it in some way into output (Sommerville, 2000).

Software architecture is defined as *the basic organization of the system together with its components, interrelationships, work environment and rules establishing the way of its construction and development* (ISO/IEC, 2007) (ISO/IEC/IEEE, 2011). Software architecture is an essential framework for structuring the system. Various architectural models can be developed during architectural design, for example, a structural model, a control model and a division model. Furthermore, Cloud Computing is the practice of implementing the component architecture of the system (Żeliński, 2019).

System architecture can consist of three basic layers: presentation layer, business logic layer, data layer (Dąbkowski, Kowalski, 2005). For example, *the Intelligent Transport Systems (ITS) architecture is a conceptual project that defines the structure and operation of an ITS system at the urban, regional, national or international level. It often covers not only technical aspects, but also related legal, business and organizational issues* (CUPT, 2019, author's trans.). Examples of architectures are as follows: computer system architecture, operating system architecture, von Neumann's architecture, database system architecture (client-server architecture, 3-layer architecture), application architecture, reference system architecture, reference workflow system architecture, integration architecture (model UML components) (Garcia-Molina, Ullman, Widom, 2014).

It is also vital to pay attention to the methodology of designing and implementing information systems functioning on the Internet and increasingly used to build a geographic information system (GIS). Desktop, client and server solutions (2-layer architecture) are replaced by systems with 3- and n-layer architecture. The functionality of the software developed in the 3-layer architecture is divided into: user interface, application server and database. The browser is used as the user interface (Geoforum.pl, 2019a).

There are also dynamically developing services enabling access to the Internet (in Poland: SDI (Spatial Data Infrastructures) (initially Fast Internet Access, later Fixed Internet Access). These services are growing and according to the Global Spatial Data Infrastructure (GSDI) (Gaździcki, 2003) they can be divided into six categories: human interaction services (including catalogue viewer, geographic browser), model management services, task management services, processing services (spatial, thematic, time, metadata), communication services, system management services (Geoforum.pl, 2019b). Defining services that meet user requirements are part of service-oriented architecture (SOA) (Erl, 2014).

1.3 System architecture model

Systems architecture models are created depending on the needs and specific applications in a given field. For example, the object-oriented model of the IT system architecture includes: identification of classes and objects, identification of class and object associations, identification of class attributes, identification and definition of methods and messages - object interfaces. In turn, the model of the real-time system architecture envisages associating the process with each class of detectors and effectors, and other coordination processes may be needed. This model enables fast receiving data from detectors (before next input data is ready), their subsequent processing and response by effectors (Sommerville, 2000).

In contrast, the service system architecture model (Enterprise Service Bus) is a system architecture model used to design and implement interactions and communication between various applications cooperating with each other having SOA architecture. As the system architecture model, this is the implementation of a more general model of client-server architecture, assuming communication and interaction between applications via data communications (IBM, 2019).

In the following chapters, we will discuss selected models of e-learning systems architecture and the architecture of e-learning systems with AI elements.

2. MODELS OF ARCHITECTURE OF E-LEARNING SYSTEMS

2.1 ITS system architecture model

ITS (Intelligent Tutoring System) is a complex, integrated software system that applies the principles and methods of artificial intelligence (AI) to the problems and needs of teaching and learning. They allow you to search the level of knowledge and learning strategies used to increase or improve students' knowledge. They are aimed at supporting and improving the teaching and learning process in the chosen area of knowledge, while respecting the individuality of the learner (Dašić, Dašić, Crvenković, Šerifi, 2016).

Traditional Intelligent Learning Systems (ITS) focus on rewarding and training, which is why their management mechanisms are often based on domains. More current ITS pay special attention to the familiar approaches to teaching, trying to separate architectural, methodological and manipulative problems from domain knowledge and real-life. The mainstream of current research in this discipline is dominated by problems such as collaborative studying, internet-established instructing and finding out pedagogical agents (Brusilovsky, Eklund, Schwarz, 1998) (Polson, Richardson, 1988).

ITS, based on knowledge, use: (1) knowledge about domain knowledge; (2) knowledge of the teaching principles; (3) methods by means of which these principles are applied and knowledge of methods and techniques of modelling the flow of students in order to acquire knowledge and skills. The traditional intelligent teaching system (ITS) was built based on four interlinked software modules and discussed in the work of Etienne Wegner. These modules were distinguished: (1) Domain Knowledge - Domain Module (DM) (knowledge), domain knowledge, with which the student will communicate during learning and teaching; (2) Student Model - Domain Module (SM) (student knowledge), dynamic model of acquiring knowledge and skills of students); (3) Pedagogical Knowledge - Teacher Module (TM) (tutoring skills), a unit that controls the process of acquiring knowledge and skills of students; (4) Interface - User Interface (UI) or Communication (CM module), system and environment of the student learning process, "knowledge-teacher-knowledge" interaction (Wenger, 1987).

Research on ITS continued in the 1980s and beyond. This is evidenced by the work of such authors as: (Polson, Richardson, 1988), (Psotka, Massey, 1988), (Murray, 1999), (Zhang, Ren, Chen, 2005), (Phobun, Vicheanpanya, 2010).

However, the first ITS systems as single-application adapting to the needs of the learner were based on the algorithms contained in the application and used the content embedded there. These include applications such as SOPHIE (Brown, Burton, Kleer, 1982) and GUIDON (Clancey, 1986). Similar systems are still being created, among them Cognitive Tutor, Help Tutor, Logicando, ASSISTments Platforms, and Franctions Tutor (Marciniak, 2015, p. 158).

Over time, different approaches have appeared that implement various architectures, e.g. IEEE LTSC CMI, IMS LIP (Learner Information Packadge), IMS Simple Sequencing, LMS (Learning Management System), SCORM (Sharable Content Object Reference Model), SCORM CAM (SCORM Content Aggregation Model) (Marciniak, 2015, p. 160). During the research, however, it was noticed that for ITS operating in the e-learning environment, there are no solutions in which the ITS system will work with the use of repositories of e-learning content, powered on a continuous basis. Although the approaches using IMS Simple Sequencing allow for adaptive matching of content for the learner, but due to the SCORM architecture, this can only be implemented within the SCORM CAM structure, i.e. within the SCORM package in which the e-learning course is transferred. Therefore, a solution was proposed where ITS is immersed in the e-learning content repository. This solution will be presented in the next chapter.

2.2 The architecture model of the intelligent e-learning system

In the architecture proposed by Jacek Marciniak, the ITS system has been implemented as an intelligent agent and is a module called Agent ITS embedded in the LMS system. The assumptions of this system are as follows: (1) the wordnet ontology is treated as a model about the world (domain model) and used for downloading content from the repository; (2) didactic strategies are built using IMS Simple Sequencing in SCORM CAM structures; (3) didactic content is created using the Extension Points and Triggers mechanisms, used to transfer to ITS the conditions for searching repositories and ITS operation strategies.

In addition, the system architecture is based on the assumption that the solution is built on the basis of the existing LMS remote teaching system, implementing SCORM 2004, which after the extension has ITS features. ITS provides content from the repository with the following rules: (1) didactic contents stored in the repository are in the form of training units; (2) the repository is powered by e-learning courses containing units of learning independently from each other and on various topics; (3) the courses are constructed in such a way that the components contained therein can function independently of the course; (4) new courses are constructed in a dynamic way and adapt to the needs of the learner identified during learning; (5) adaptation is carried out using all materials contained in the repository (Marciniak, 2015, p. 162).

Detailed discussions of the architecture of the intelligent e-learning system can be found in the works: (Marciniak, 2014), (Marciniak, 2015), (Marciniak, 2016).

According to the author of this solution, the whole project has all the components of the traditional ITS system architecture, i.e. Domain Module, Student Model, Pedagogical Model and Interface. At the same time, the Domain Module is built as a model of knowledge about the world using the wordnet ontology. Thanks to this structure, it is possible to map domain and expert conceptualizations of a general and local nature. Domain knowledge may come from thesauri, domain ontologies, classification systems, and it is possible to write relationships between concepts in the content of a given repository. The wordnet ontology is used in a normalized form, which means that it contains all information about scales determining the degree of connection between concepts.

The Student Model consists of data stored in the LMS system. They can be organized in various ways, e.g. according to the IMS ePortfolio specification.

The Pedagogical Model consists of didactic strategies, didactic patterns and the ITS Agent. Didactic strategies are patterns of behaviour implemented by the system during interaction with the learner. They are saved using the IMS Simple Sequencing in the organization of the course for selected content components. The didactic patterns are sets of predefined rules written in IMS Simple Sequencing, which after the introduction of a specific e-learning course to the organization will create a didactic strategy. An ITS agent is an IT module that extends the LMS architecture by signing in to the SCORM Navigation Model, which supports requests to provide further content to the learner.

The system interface is determined by the way the contents are presented in the SCO delivered to the learner. These contents can be saved as multimedia and interactive elements, text supplemented with graphic elements, video sequences (Marciniak, 2015, p. 167).

The presented intelligent e-learning system allows to conduct education in an adaptive way, thanks to which, when providing content, it is possible to take into account the specific needs of learners. Of course, also other models of e-learning systems architectures function today. An overview of such architectures will be presented in the next chapter.

3. OVERVIEW OF CONTEMPORARY MODELS OF ARCHITECTURE OF E-LEARNING SYSTEMS WITH ELEMENTS OF AI

3.1 Architecture for recommendation of courses in e-learning system (2017)

The goal of the system is to recommend e-learning courses to the student based on his/her profile. The student's profile is created by applying the k-means algorithm to the student's interaction in Moodle. To do this, follow the steps below: (1) To collect data from Moodle server. (2) to perform data preprocessing in order to make data suitable for data mining algorithms. (3) To build learners' profile by applying k-means algorithm.

Architecture is implemented in Moodle allows you to evaluate the work of students. The following attributes can be used: Number of quizzes completed, Messages sent to chat, Messages sent to teacher, Messages sent to forum, Messages read on forum, Time spent on quizzes, Time spent on forum, Total Marks obtained. The pre-processing of data includes several steps, including data cleaning, user identification, session identification, path completion, transaction identification, data transformation, data integration and data reduction. The Moodle platform provides login to each user and allows identifying the user and each session. However, the following tasks need to be performed: (1) Data selection. Select specific courses and parameters characterizing the student's work, e.g.: the time spent by students on quizzes. time spent by students on assignments, message sent by students to the teacher, messages sent by students on the forum, etc. (2) Create Summarization Table. The summary table contains a summary for each line of activities performed by each student during the course and the final grade obtained by each student on each course. (3) Data Discretization. Data discretization helps us to transform numerical data into categorical data. Different methods can be used. In the manual method, we assign attribute values to four categories EXCELLENT, GOOD, AVERAGE and POOR. (4) Transform the Data. The data initially saved in the Excel file must be converted to a CSV file. Then we convert them to the ARFF file format. Initial data processing includes several sub-steps such as data cleaning, identification, user identification, session identification and path completion. Further processing of files takes place in the WEKA (Waikato Environment for Knowledge Analysis) system. WEKA is data mining software that implements data mining algorithms (see: https://www.cs.waikato.ac.nz/ml/weka/).

The elements of the system are: User Authentication, Logging Check, Learner's interaction with Moodle, Data Stored in Moodle Database, Data Prepocessing, Applying K-Means Algorithm, View Module.

The research results show that advanced courses should not be recommended to inactive students who have poor grades.

Applications: as a research project intended for further research.

Developed by Bhupesh Rawat, Sanjay K. Dwivedi/Babasaheb Bhimrao Ambedkar University, India (Rawat, Dwivedi, 2017).

3.2 Architecture for e-learning system with intelligent component (2016)

Intelligence is built into the architecture of the e-learning system, thanks to which the system automatically responds to the user's requirements. The system responds to each individual user and is able to predict his preferences or interests.

The system architecture consists of the following components: User Interface, User profile, E-provider, Acquisition, Filtering, History database, Creator, Evaluator, Good rank, Bad rank and Selector. The component selector has the ability to analyse user feedback and create knowledge after user evaluation. It consists of four subsystems, which are: Evaluator, good rank, bad rank and intelligent component. The evaluator has the opportunity to receive feedback from the user based on what has been read, can identify a good and a bad resource. Good rank gathers electronic resources that are classified by the user as good electronic resources. Bad rank stores the lowest ranking for e-resources that are classified by the user as bad e-resources. A good rank stores a user profile and information history. This component can learn from the user's habit. The result from this component should be delivered to the Creator component. This automated assessment is based on the modelling of the activity history and its evaluation by the user.

Applications: as a research project intended for further research.

Developed by Mafawez Alharbi, Mahdi Jemmali/Majmaah University, Saudi Arabia (Alharbi, Jemmali, 2016).

3.3 E-learning system using machine learning and user activity analysis (2015)

The aim of the project is to present an autonomous and intelligent e-learning system in which machine learning and user activity analysis play the role of an automatic evaluator for the level of knowledge. The assessment of the level of knowledge is carried out in order to adapt the presented content to a realistic assessment of students in the online system.

The assumptions of the system are as follows: (1) User experience. E-learning users should have access to the educational system via various means with access to the Internet. Access should be flexible, tailored to users' lifestyles, global reach and / or independent collaboration between content providers. (2) Cloud-based environment. The cloud-based e-learning system offers a wide range of possibilities, for example competitive costs along with a high level of scalability. At the same time, it includes a subset of services (Intelligent Agents) dedicated to registering user activities (activity logs, exam results). (3) Incorporating concept maps. Maps are tools for understanding the knowledge for each system user. A simple map it consists of terms marked with circles, while the basic relationships are marked with links with annotations. It is possible to use conceptual maps in combination with multimedia. (4) Generating activity reports. The user activity summary contains several variable derivatives representing activity, assessment of conceptual maps, and exam results. The following aspects are analyzed: (a) The feature extraction (for example, the average time spent per study objective). (b) Categorizing the extracted features. (c) Concept map analysis. (d) Normalizing the results of the exam sets. (e) Attention level (for example, average time of focus). (5) Knowledge level assessment. The Machine Learning method for classification provides the desired results using the user's activity model. Before constructing classification models, in domain categories, two possible configurations depend on knowledge that is to be general or specific.

Elements of the system are as follows: Dynamic E-learning Environment, Extra Activity, Mobile, Web Based, Activity Monitor, User, Logs and Content, Pre-processing, Activity Report, Classification, Knowledge Level.

Applications: as a futuristic design for further testing.

Developed by Nazeeh Ghatasheh/The University of Jordan, Jordan (Ghatasheh, 2015).

3.4 E-learning Enterprise Architecture using SOA (2014)

The architecture of the e-learning system was designed using the Service Oriented Architecture (SOA) approach using cloud computing. The project also used mechanisms of related architectures, such as: Service Oriented Cloud Computing Architecture (SOCCA), Cloud-oriented e-Learning Model Architecture (COLMA).

The goal of the project is to provide e-learning services based on SOA architecture using cloud computing. Such architecture should include three components: (1) Technology or infrastructure architecture that can be gradually acquired and used to meet the need for modern learning applications; (2) a data architecture that can handle structured as well as unstructured data in a centralized manner and handle data and metadata needs of the future application; (3) Application architecture that should be open and expandable so that it can meet the ever-changing requirements of the education industry.

The elements of this project are: SOA Based Solution, Internal Assets, External Systems, users, such as: Students, Faculty, Administration, Other Stakeholders. The SOA Based Solution module includes: Application Architecture, Data Architecture, Infrastructure Architecture.

Applications: as a research project intended for further research.

Developed by Erick Fernando/University of Jambi, Indonesia (Fernando, 2014).

3.5 MVC (Model–View–Controller) based design pattern for context aware adaptive e-learning system (2013)

The innovative architectural model is based on the MVC (Model-View-Controller) design model, which is able to perform a personalized adaptive delivery of the course content in accordance with the contextual information of the student, such as the learning style and features of the learning device using the ontological approach.

The ontological approach ensures the management and organization of course materials based on their semantic relationships. Representation of the various topics of the proposed ontology of the course can be formally represented as G (T, P, R), where T = Set of topics of specific course or subject; P = is the property set such as ID, Name, Description, etc.; R = is the relation set indicating the semantic relationships between the pair of topics. However, thanks to the e-learning applications used based on device-independent courses, students can view their materials and can get additional help on difficult topics.

The main purpose of the proposed system is to improve the student's knowledge and to facilitate the learner's review of the course content at any time. Two strategies were used to achieve this goal: (1) Ontology based content organization and presentation of course material; (2) Device independent adaptive delivery of learning resources.

This system consists of: (1) Controller (context detection and adaptive mechanism): the controller is responsible for noticing what type of educational device has received the request, and then redirects to the appropriate view (web page). (2) Model (information storage and processing of queries): describes the student's context, the logic of adaptation and repository of the teaching content. (3) View (user interface): this is the output representation of the model data, it is a web browser with an internet connection.

In the context of the proposed contextual architecture of the adaptive e-learning system, the client device sends an HTTP request to the Web server (e.g. IIS). The context detection mechanism (Controller) implemented on the web server receives the request and identifies the device type based on the user agent's profile headers. The device context is saved along with the student's preferences within a given student context identifier as student context information (Model). When the student accesses the teaching content, the controller's Action class forwards the request to the adaptation logic that is responsible for providing the relevant content from the given database and in accordance with the presentation logic (View).

Applications: the system's prototype is implemented at the university.

Developed by Kalla Madhu Sudhana/St. Peter's University, India; V[ences] Cyril Raj/Dr.M.G.R University, India; T. Ravi/Srinivasa Institute of Engg & Tech, India (Sudhana, Cyril, Ravi, 2013).

3.6 Model of e-learning system with Extendable Open Source Architecture (2013)

Open Source extensions, developed and maintained by the open source community, increase the functionality of the e-learning system. In the appropriate system components, the server side extension manager checks the correctness of portability, e-learning standardization and security issues before approving the extension to the e-learning community. In contrast, the client side extension manager checks for new extensions/updates and allows these extensions/updates.

This system consists of: (1) core components: provide the main functionality of the e-learning system, (2) extensions: developed and maintained by the open source community, extend the functionality of the e-learning system, (3) server side extension manager: validates the portability, e-learning standardization and security (4) client side extension manager: checks for updates and update/disallow these extensions/updates.

According to the creators of this project, the expandable architecture of the open source e-learning system can better meet the expectations of the e-learners community.

Applications: as a research project intended for further research.

Developed by Murtaza Ali Khan, Faizan Ur Rehman / Umm Al-Qura University, Saudi Arabia (Khan, Rehman, 2014).

3.7 Adaptive e-learning systems (2010)

The aim of the project is to develop an agile e-learning system with flexible architecture, flexible use of resources and adapted content for learning in the university environment. It is true that the definition of the agile IS (information system) is still not developed, but some assumptions have been made in the architecture model. The definition was adopted that *The agile e-learning system is a system that has adaptable, reusable and easy changeable content* (Finke, Bicãns, 2010, p. 311).

According to the Agile Software Development Manifesto (access: https://agilemanifesto.org/), particular attention should be paid to: (1) Individuals and interactions over processes and tools; (2) Working software over comprehensive documentation; (3) Customer collaboration over contract negotiation; (4) Responding to change over following a plan. The concept of agility can be described as reliability, adaptability and flexibility. All these factors, through interaction, ensure system variability. These aspects can be implemented in e-learning by predicting algorithms that work with parameters defined for objects and by combining these objects together, as well as by using keywords or other element of metadata or combination of elements.

Elements of the system are as follows: E-learning system management, Services, Business process, University and Cloud. Cloud consists of four components: Storage (User profiles, Backups, LO Repository, Assessments), Social (Skype, Twitter, Blogs, Messenger), Multimedia (Audio, Video, Animations, Rich interactive applications, Still images), Load balancer (which, by purchasing some of its resources from the cloud, allows us to adjust available resources according to load indicators). Services include with Assessment, User management, Learning objects storing. Whereas, Learning objects development, Learning curriculum development, Feedback collection, Collaboration with industry, Research, Team work case studies, Scientific activities belong to Business process.

A system that changes architecture, acquiring part of its resources from the cloud, allows you to adjust the available resources in accordance with the load indicators. These changes mean partial assignment of business processes and storage of relevant information to the management of the system holder - university.

Applications: as a research project intended for further research.

Developed by Anita Finke, Janis Bicans/Riga Technical University, Latvia (Finke, Bicans, 2010).

3.8 A semantic web architecture to integrate competence management and learning paths (2008)

The aim of this project is to develop a prototype application based on competency ontology, which will be used to manage competences and learning paths in conjunction with the e-learning method. Modifying an employee or department/organization skills gap analysis with relevant learning subjects is critical to developing the right learning pathways, and consequently the appropriate competencies of employees or organizations.

The ontological approach ensures the management and organization of course materials based on their semantic relationships. Representation of the various topics of the proposed ontology of the course can be formally represented as G (T, P, R), where T = Set of topics of specific course or subject; P = is the property set such as ID, Name, Description, etc.; R = is the relation set indicating the semantic relationships between the pair of topics. However, thanks to the e-learning applications used based on device-independent courses, students can view their materials and can get additional help on difficult topics.

The technical architecture of the system consists of the following components: Web Browser, Web Server, Java (Servlet Container, JSP Pool (JavaServer Pages Pool Service), Ontology management, Ontology (RDF (Resource Description Framework)), Data Retrieval. Front-end has been designed as jsp pages and thanks to it, users can access various system functions, while some jsp pages contain JavaScript functions. Apache Tomcat was used as a servlet container. Back-end is implemented in Java, and access to the ontology is provided by the Jena and RDQL (RDF Data Query Language) APIs (application programming interfaces). Jena is an open Java API for RDF, available on the Internet (see http://jena.sourceforge.net/) and RDQL is the query language for RDF in Jena models.

Functional architecture of the system consists of the following components: Core System Function and Reporting Function. Core system functions include functions for inserting, updating and deleting ontology data. It also uses the functions of creating, updating and deleting the relationship between two competences, work assignment and the relationship between the subject and the competence. Reporting functions include providing the system user with a variety of view functions, such as *View Competency Model* and *View Jobs'*

Infos that generate a table with all the tasks of the organization. In addition, various reports are provided on the analysis of skills gaps, succession planning (including identification of successors in key positions, career path planning, university development), experts and projects.

Applications: the proposed application has been implemented in the Microsoft.NET version at Microsoft Hellas, a branch of the leading IT company Microsoft Corporation in Greece.

Developed by Fotis Draganidis, Paraskevi Chamopoulou, Gregoris Mentzas/National Technical University of Athens, Greece (Draganidis, Chamopoulou, Mentzas, 2008).

CONCLUSION

Research and analysis of currently used and designed models of e-learning systems architectures are limited. The article presents only selected at random e-learning system architectures described in the registered documents selected in the databases. Despite these limitations, it can be seen that the architecture of e-learning systems is designed using new technologies, such as: agile Information System, Cloud Computing, Extendable Open Source, ontology based content organization, competency ontology, Service Oriented Architecture (SOA), semantic web architecture. In addition, some of these systems use (in assumptions/theory or in practice) elements of AI. These elements are concept maps, deep learning, intelligent agents, knowledge management, machine learning method, ontologies. Detailed comments on the advantages and disadvantages of these architectures and a list of AI components used are presented in Table 1.

Table 1.
Advantages and disadvantages of selected models of architecture of e-learning systems with elements of AI

Model of architecture	**Advantages**	**Disadvantages**	**Methods, technologies, elements of AI**
Architecture for recommendation of courses in e-learning system (2017)	the option of recommending courses to students based on their profile	disadvantages arising from the operation of the WEKA platform (- data mining suites do not implement the newest techniques; - the documentation for the GUI is quite limited; - GUI does not implement	machine learning (algorithms for data mining tasks in WEKA)

		all the possible options; - scaling; - the data preparation and visualization techniques offered might not be enough)	
	the ability to implant this architecture in Moodle		
	the opportunity to find students who are less active on collaborative platforms		
Architecture for e-learning system with intelligent component (2016)	it has ability to predicate e-recourse for the user	for implementing the intelligent component AI techniques must be used (not specified yet)	machine learning/auto evaluation - is a multi-start (the intelligent component can make some knowledge after more evaluation by the user)
	auto evaluation based in history modeling and history evaluation make by user	is a multi-start local search method which requires iteratively solving a sequence of multi instances	
	the e-learning system is automatically responsive to the user requirements		
E-learning system using machine learning and user activity analysis (2015)	flexible and adaptable learning environment to the users' lifestyle	tree-based and Naive-based algorithms show several variations among the different measures, which makes it more difficult to judge which one has an overall better	machine learning, Intelligent Agents, conceptual maps, cloud-based

		error margin.	environment
	device-independent suitability (to offer a wide range of options to those unable to learn and work under strict time schedules, for example employees, housewives, travelers, and learners with high possibility of relocation)	future work needs to investigate the importance of input variables to the classification method	
	independent collaboration between content providers		
	the ability to use concept maps that have different advantages over traditional approaches		
E-learning Enterprise Architecture using SOA (2014)	the application can be continuously updated by the application provider	disadvantages resulting from the operation of cloud computing platforms, among others: high costs, a complicated pricing model for cloud services, data security	cloud computing platform, SOA, SOCCA, COLMA
	the application provider is offering a very scalable web application using a multi-tiered web architecture, implemented on a considerable infrastructure		
	service-oriented cloud computing e-learning architecture include decentralized, cost effective, virtualized, flexible, personalized and scalability elements		
IMVC (Model–View–Controller) based design pattern for	using server-side adaptation is the server usually has much more processing power than the	disadvantages of MVC operation: complexity, low flexibility of the model	adaptive learning, MVC

context aware adaptive e-learning system (2013)	client devices, so that server can dynamically perform adaptation according to learner device capabilities		
	advantages of MVC operation: model independence (the application can have multiple independent views for the same model); high flexibility of views (views can be modified more often and at a lower cost)		
Model of e-learning system with Extendable Open Source Architecture (2013)	the development and deployment of dynamic contents based on HTML or XML - these features of XML allows more efficient searching, intelligent data mining, querying (e.g. SQL) etc.	disadvantages of OpenSource software: openness of the code may mean a greater risk of attack, OpenSource is rarely compatible with future versions	extendable OpenSource Architecture of e-learning system
	open source architecture of e-Learning system that allows the user to enhance the functionality of existing e-Learning system through extensions		
Adaptive e-learning systems (2010)	economy of time, because we do not have to define the link to the object (feature of Moodle)	disadvantages resulting from the use of Cloud Computing, ontology and Semantic Web technologies	Cloud Computing, ontology, Semantic Web (OWL language)
	structuring of the curriculum allows us to plan the topics of the course more effectively and therefore allows to provide comprehensive		

	and detailed layout of the course		
	users of the system do not have to perform manual linking by adding or deleting objects and their parameters		
	the search system depends only on the entered parameters; search services indicate and combine queries with available objects		
A semantic web architecture to integrate competence management and learning paths (2008)	possibility of extending the system with the semantic search function and the inference engine	unresolved issues that need further research in ontological systems, such as RDF cascading	Semantic Web, RDF, RDF Data Query Language
	the ability to assess the effectiveness of ontological systems in real environments		

Source: Own work

It is worth paying attention to interesting projects, e.g. using agile IS. The dynamic aspect of the development of agile IS structures is achieved mainly thanks to ontology and rules defined in the OWL (Web Ontology Language) language. These assumptions are in line with the latest trends in education, according to which educational systems must be agile enough to support future practices (Noskova, Pavlova, Yakovleva, 2018) (Smyrnova-Trybulska, 2018). Some researchers believe that Cloud Computing combined with rule-based systems is the future way of dynamic development of e-learning. In the future, it will also be necessary to examine the limits of the dynamics of the e-learning system, because at the moment it is only possible to determine the dynamics of the system within certain limits.

It seems that the development of e-learning system architectures will continue. This is a favourable tendency in the existence and development of these systems, especially from the point of view of their capabilities and usability.

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EXPLORING ADDITION AND SUBTRACTION STRATEGIES WITH VIRTUAL MANIPULATIVES ON TABLET DEVICES IN SECOND GRADE

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Abstract: *The purpose of this study was to observe how second-grade pupils with little previous digital experience explore various addition and subtraction strategies using several virtual manipulatives on tablet devices. During a one-week instruction pupils interacted with four virtual manipulatives and reacted differently to the each of them. Pupils' opinions, preferred addition and subtraction strategies and difficulties with the use and understanding of virtual manipulatives are described in this contribution.*

Keywords: virtual manipulatives, addition and subtraction strategies, tablets

INTRODUCTION

Since the introduction of virtual manipulatives many researchers have studied their potential or impact on student's learning (Baturo, Cooper & Thompson, 2003; Moyer, Niezgoda, & Stanley, 2005; Moyer-Packenham et al., 2014; Steen, Brooks, & Lyon, 2006; Suh, 2005). Tablet and mobile devices have brought new possibilities for their use and potential to engage students in mathematics and increase their motivation (Attard & Curry, 2012; Calder & Campbell, 2015; Goodwin, 2012; Hilton, 2018). Tablet devices are easy to use and children interact with tablet devices more freely and independently than with personal computers (Geist, 2012). It is necessary to explore its potential and study, how can these tools be effectively used to enhance students' learning and understanding of complex and abstract mathematics concepts.

1. LITERATURE REVIEW

1.1 Teaching with virtual manipulatives on tablet devices

Many mathematics apps contain a virtual manipulative that students can manipulate to support the visualization of mathematics concepts (Anderson-Pence et al., 2014). Students who struggle with abstract concepts can understand these concepts when given the opportunity to manipulate and explore mathematic objects in a problem solving environment (Bos, 2009). The use of iPads allows teachers to introduce and implement a wide range of teaching strategies (Attard & Curry, 2012; Spencer, 2013) and explore various strategies when solving problems. The multisensory interaction with tablet devices provides interactive manipulatives supporting transition between concrete and visual representations and abstract knowledge (Volk, Cotič, Zajc & Starčič, 2017).

A recent study conducted with ten students of primary pedagogy tutoring 10 lowachieving primary school pupils revealed that supplemental teaching with iPads can help pupils understand numeracy concepts and improve their math skills (Kaur, Koval, & Chaney, 2017). Similarly, Spencer (2013) reported that the usage of iPad can improve students' numeracy learning. The results from a research done in two Californian primary classrooms showed that iPads can support the development of concepts, critical thinking and pupils' learning and achievement (McKenna, 2012).

There are many advantages of tablet learning. Culén and Gasparini (2011) reported that the use of iPads supported collaboration, interaction and discussion among pupils. Children work on tablets intuitively in groups and want to share their experience with their peers (Shifflet, Toledo, & Mattoon, 2012). Discussion and collaboration along with the use of multiple representations and various teaching strategies support pupils' development of concepts and construction of solid mental representations. To understand the concepts and relations through manipulatives, it is necessary to use them effectively, so that they would really represent the concept and help the students. Greeno and Hall (1997) argue that pupils need to use multiple representations in various situations while communicating and reasoning in the context of a social environment.

1.2 Addition and subtraction algorithms

When teaching addition and subtraction strategies up to 100, teachers can choose from several strategies and demonstrate these with multiple enactive, iconic or symbolic representations. When pupils use appropriate models, they are able to discover when and how to use the concepts of composing, decomposing, regrouping or 'make ten' strategy. Manipulatives displaying the principles of addition and subtraction in our number system are e.g. the base ten block, number rack and number frames. Additional strategies can be discovered also by using the number line. These are now accessible as online learning tools or apps available for tablet devices.

One of the virtual manipulatives, the virtual base ten block, shows pupils the principle of regrouping tens and one when adding or subtracting. In a virtual manipulative, pupils don’t need to replace one rod with ten units. They can tap on the rod to change it into ten units or circle ten units to connect them into one rod.

Number rack and number frames are used in similar manner. Double-coloured counters placed on a number rack demonstrate concepts of composing and decomposing and at the same time, pupils see the two addends in an addition problem or the minuend and subtrahend in a subtraction problem. When modelling the numbers with double-coloured counters, pupils can see, which of the two numbers they need to decompose and they can change the colour of counters when needed.

A different strategy for addition and subtraction needs to be implemented on a number line. Its way of use represents mental addition and subtraction. At first, pupils need to add or subtract tens, and then the ones by jumping from the starting number. Rather than jumping 36-times, pupils can jump three-times ten and then jump six-times by one space.

These and other strategies can be useful for pupils when learning addition and subtraction algorithms. When a teacher introduces more strategies, pupils get the opportunity to choose the most suitable strategy according to their abilities and get more chances to understand the concepts and relations through representations that can be meaningful to them. There are many virtual manipulatives at teacher’s disposal, however, it is necessary to use them according to the pupils’ abilities or their learning styles.

This study aimed to explore, how pupils using mostly symbolic representations interpret and react to virtual manipulatives. The purpose of the study was to observe, how pupils with lack of digital experience explore addition and subtraction strategies with virtual manipulatives on tablet devices. There were two research questions:

- How will pupils interact with different virtual manipulatives on tablet devices?
- What addition and subtraction strategies will they use?
- Which advantages and disadvantages will they discover?

2. METHODS

Research design is based on qualitative approach consisting of intervention and direct and indirect observation. 24 second-grade pupils participated in a one-week instruction during regular mathematics classes at the end of the school-year and used virtual manipulatives on tablet devices while exploring different addition and subtraction strategies through different virtual manipulatives. The instruction took place on the second and third lessons to prevent tiredness and lack of concentration. The lessons were instructed by a research member while the class teacher was observing the lessons. The class teacher received a printed structured observation sheet for this purpose. Pupils were asked to use tablet devices in pairs to encourage cooperation and discussion between them. We wanted to observe how pupils would explain the problems or manipulation use to each other. The class received an introduction for every virtual manipulative from a research member who explained how to work with the virtual manipulative frontally on the interactive whiteboard. Pupils were showed several examples and solved some tasks frontally before they used the virtual manipulatives in pairs. After each lesson pupils were asked to express their opinions concerning the use of the virtual manipulatives, explain whether or why they found the manipulative to be useful and state any difficulties they had encountered.

All lessons were video-recorded by two research team members focusing on pupils' activities, way of working with the manipulatives, pupils' discussions and ways of solving tasks on tablet devices. After the end of the instruction the class teacher was interviewed individually. The interview was audio-recorded and transcribed. Additional data was collected from class teacher's notes recorded during the instruction. A structured observational sheet has been prepared for the class teacher. The qualitative data was analysed and coded using open and selective procedures into categories to identify emerging themes which were used for interpreting the data.

2.1 Participants and setting

The study was conducted in a second grade class in a small-town school with a lack of digital equipment. The school's population is approximately 250 pupils and the only digital equipment accessible to the pupils are a computer classroom and a class with an interactive whiteboard. None of these are used by primary pupils. The instruction took place in the only classroom with the interactive whiteboard.

At the time of the study the class teacher was in her second year of teaching and preferred teaching through iconic and symbolic representations using mostly textbooks and workbooks. 24 pupils (13 boys and 11 girls) participated in the instruction. 20 pupils out of 24 had experience with tablet-based instruction from previous research they participated in the first grade, but they had not used any digital equipment at school on a regular basis. Only a few of them had access to tablet or mobile devices at home, but most of them had difficulty handling the device. The parents of the pupils have been informed about the research and have signed an informed consent before the beginning of the instruction. All parents have agreed for their children to participate in the study.

2.2 Instruments and data sources

During the instruction pupils used tablet devices with Android based operating system and the instructor used a Windows-based laptop connected to a Smart board. All tablets and the laptop were connected to the Internet through the school's wireless network and in case of any difficulties with the connectivity, a few extra tablets were prepared. We have chosen to use online virtual manipulatives which were compatible with both the Windows-based laptop used by the instructor and the Android-based tablet devices. We decided to use the free math apps available through The Math Learning Centre's resources (https://www.mathlearningcenter.org/resources/apps). However, we could use only the web apps, but couldn't download the apps to the tablets due to compatibility problems.

Pupils used four virtual manipulatives available on the website:

- Number Frames.
- Number Line.
- Number Pieces.
- Number Rack.

Two research team members recorded all lessons with two digital cameras from different perspectives. Additional materials include the structures observation sheets prepared for the class teacher, the structured interview guide prepared for the interview with the class teacher and the lesson plans prepared by the instructor.

3. RESULTS

When pupils received the tablets, they showed increased motivation and excitement and verbally expressed their happiness of tablet usage. The instructor demonstrated the basics of tablet usage, but most of the pupils remembered its use from the previous research. During the instruction they had a few difficulties handling the device, such as accidentally closing the browser or problems with connectivity, but they did not have any significant difficulties. On each lesson they explored other virtual manipulatives. The manipulatives were explored in the following order: number frame, number rack, base ten block and number line. The number frame and number rack were used during the first day of instruction, the base ten block on the second day and the number line on the third day. The four manipulatives will be analysed separately.

3.1 Virtual number frame

Pupils had little previous experience with number frames and double - coloured counters in form of physical manipulatives from previous research. They had not used them on regular math lessons with their class teacher. In this research, Number Frame (https://www.mathlearningcenter.org/resources/apps/number-frames) virtual manipulative from The Math Learning Centre website was used. Pupils worked only with the 100-frame. Pupils needed little instruction on how to use the counters, but had difficulties placing a set of ten counters on the right place in the frame (see Figure 1). One of the first advantages discovered by pupils was the possibility of moving more counters at the same time. They declared that this feature of the virtual manipulative made the use easier and faster. Pupils were asked to solve several addition and subtraction problems.

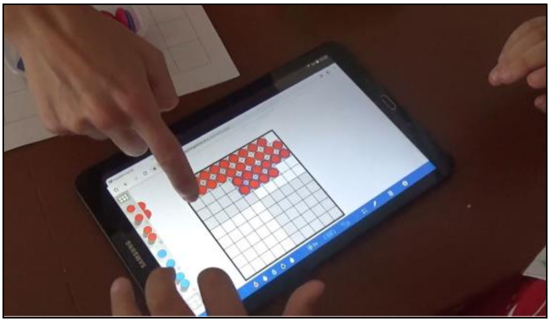

Figure 1. Placing a set of ten counters
Source: Screenshot from the video-recording. Own work

When adding a one-digit number to a two-digit number, some pupils solved tasks mentally. They did not need to use the manipulatives, because they could already solve these tasks. Approximately half of the pupils relied on the virtual manipulative and a few of them counted the counters and checked the results several times by each task (see Figure 2).

When adding two two-digit numbers, all pupils placed the counters correctly. However, many of the pupils wanted to solve the tasks mentally instead of telling the answer from the number frame, and solved the tasks incorrectly. At first, pupils had difficulties with decomposing the second addend in spite of having the counters placed correctly in the frame. The instructor decided to solve some tasks frontally on the interactive whiteboard and helped student with her questions to analyse the relations. After a few examples, pupils could explain the principles and how to decompose the second addend.

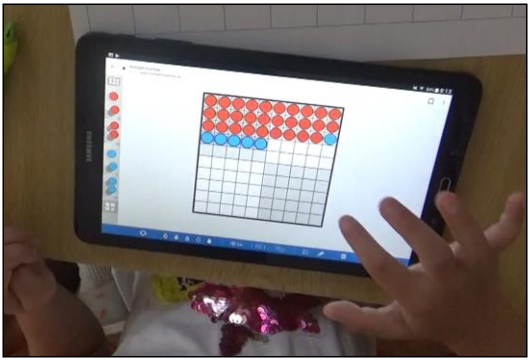

Figure 2. Adding on the number frame
Source: Screenshot from the video-recording. Own work

This virtual number frame was relatively simple for the participants. They understood its use and the order of the counters helped them understand an algorithm of mental addition. Pupils stated that this virtual manipulative was the most useful for their learning and explained that the order of counters (ten counters in ten rows) resembled the order of beads on a number rack.

3.2 Virtual number rack

Pupils were familiar with the use of the number rack from the first grade, although they had previously used only physical number racks with twenty beads. The only help needed was the way to display 10 rows of beads. Pupils found the virtual manipulative's use easier than the use of a physical number rack. They did not need any additional instruction and solved the addition and subtraction tasks easily. Pupils were immediately able to explain the number rack's use and explain the tasks using the virtual manipulative. They explained that it is easy to add tens on a number rack and were able to explain the algorithm which is used for mental addition.

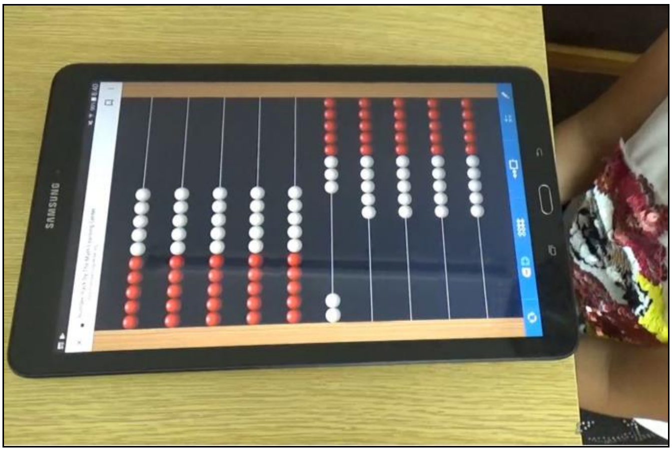

Figure 3. Displaying the result on the number rack
Source: Screenshot from the video-recording. Own work

Pupils did not mention the fact that they could not see the addends or the minuend and subtrahend at the same time with the result on the number rack (see Figure 3). They displayed the first number, added or subtracted the given number and were confident that they solved the task correctly. When solving addition problems, pupils used two strategies. Majority of pupils added the second addend by ones, adding the beads one by one. Some pupils counted the remaining beads in the row, added these beads as a set and then added the remaining beads from the next row explaining the principle of decomposing the second addend into two addends (see Figure 4). However, majority of pupils did not decompose the second addend, nor did they discover any strategies related to number five.

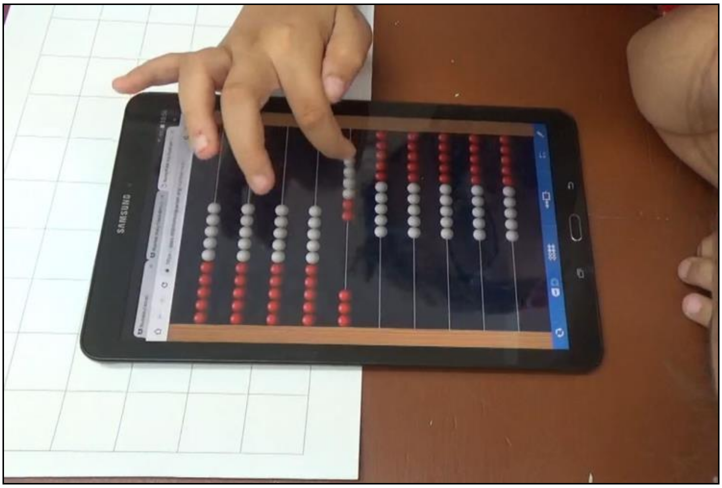

Figure 4. Decomposing the second addend
Source: Screenshot from the video-recording. Own work

3.3 Virtual base ten block

The virtual manipulative the Number Pieces (https://www.mathlearningcenter.org/resources/apps/number-rack) appeared to be complicated for the participants. They had problems with manipulating and organizing the rods and units and difficulties with counting the units. They often organised nine or eleven units into one rod with the same length as rods containing ten units not seeing the difference. Most pupils manipulated the rods and units in disorganised ways. Therefore, the most common strategy for solving the problems was counting all rods and units one by one. Pupils continued to use this strategy even after discovering that they can connect ten units into one rod by circling the right amount of units. Several pupils expressed in their opinions that working with this manipulative required too much time.

3.4 Virtual number line

The virtual number line was the last virtual manipulative used on the instruction. All pupils were familiar with the use of number line, but the only strategy they knew was moving by ones on the line (see Figure 5). After solving a few tasks frontally on the interactive whiteboard, they discovered that they could move also by tens (see Figure 6). They could explain and solve the tasks moving tens and ones frontally on the interactive whiteboard, but the majority of pupils jumped by ones when adding or subtracting two-digit numbers on the tablet devices. A few of them stated that they did not need to calculate, they could just jump on the line and write the answer. There were pupils who did not want to use the number line. They solved the tasks mentally and wrote the results.

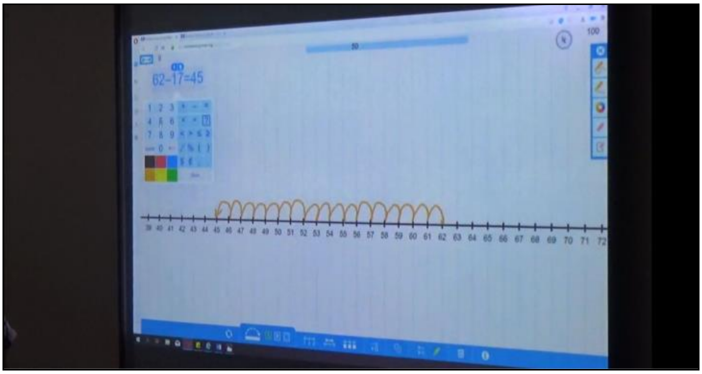

Figure 5. Moving by ones on the number line
Source: Screenshot from the video-recording. Own work

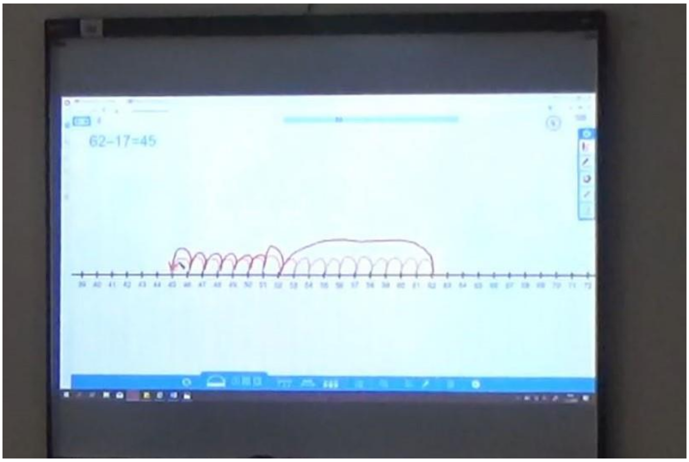

Figure 6. Moving by tens and ones on the number line
Source: Screenshot from the video-recording. Own work

CONCLUSION

During the instruction pupils were excited to use tablet devices. They talked about the activities as play and explored the possibilities of virtual manipulatives, mostly focusing on changing colour or randomly adding or deleting objects. Pupils were engaged with the tablet devices, but not always with the tasks. They explored the four virtual manipulatives on four lessons during three schooldays. It is possible that pupils' reactions and motivation were different during different days of instruction depending on their tiredness and mental state.

At first, pupils tried to solve the tasks mentally or using numbers. They needed time to adept to visual representations and some students failed to connect the visual and symbolic representations. They solved the task mentally and explained the algorithm with numbers, but could not relate the symbolic representation to the visual one displayed through the virtual manipulative. On the other hand, there were pupils who found the manipulatives useful and could explain how they worked.

There are several other studies reporting the same difficulties. A study conducted with third- and fourth-graders using virtual manipulatives revealed that many pupils had difficulties to interpret visual representations in mathematic tasks (Anderson-Pence et al., 2014). Westenskow and her colleagues (2014) found that third- and fourth-graders had difficulties especially with selecting the correct visual models and answering the problem goal. On the other hand, a study conducted with children regularly using physical manipulatives found that virtual manipulatives provided an important bridge between concrete, iconic and symbolic representations (Moyer, Niezgoda, & Stanley, 2005). They also reported that pupils preferred different methods for solving addition problems and changed their strategies when working with the virtual manipulatives for a few days.

Pupils in this study also discovered several strategies using the virtual manipulatives, but most pupils preferred to use only one or two strategies. Some pupils refused to use the number line and majority of pupils did not understand the use of the virtual base ten block. On the other hand, one girl preferred the use of virtual base ten block and had difficulties with using other virtual manipulatives.

The findings also show a difference in pupils' independence. Some pupils needed guidance during all lessons and had difficulties when working in pairs. They wanted more examples and did not want to use the manipulatives individually. Instead of using the manipulatives, they tried to solve the tasks mentally or using numbers, as they were used to. Similarly, a study comparing physical and virtual manipulatives revealed that pupils insisted on using the usual methods of problem solving refusing to experiment with new mathematics tools (Thompson, 1992). On the contrary, Highfield and Mulligan (2007) reported that pupils using virtual manipulatives explored and experimented more than pupils in the control group.

This study examined the reactions of pupils with lack of digital experience on tablet learning through virtual manipulatives. The study revealed that some pupils were able to understand the usage of virtual manipulatives immediately, while others had difficulties with connecting visual and symbolic representation. The selected virtual manipulatives supported the learning of mathematics concepts differently and were useful to different degrees according to pupils' individual needs. The use of virtual manipulatives on tablet devices can contribute to pupils' understanding and learning of addition and subtraction algorithms, but it might not be beneficial for all students. It supports differentiation, and pupils need more time to adapt to the device, learn the use of manipulatives and select the most suitable manipulative corresponding with their mental structures and thinking.

Acknowledgements

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THE ADOPTION OF DIGITAL INTERACTIVITY AS A MEDIATOR IN TEACHING AND LEARNING FOREIGN LANGUAGES IN HIGHER MOROCCAN EDUCATION

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Abstract: *The Moroccan higher educational system is reconfigured through the promotion of e-learning environment. The present study aims at demonstrating the contribution of the implementation of digital interactivity in enhancing the quality of teaching foreign languages. It also shows how foreign language classes are using technology tools to meet students' needs. This exploratory study uses a quantitative approach, with 100 participants from different Moroccan institutions. The study accepted the hypothesis that the use of digital interactivity positively impacts learners' foreign language acquisition. The results show that students need to master the interaction with digital devices. This study values digital literacy in a way it develops teaching methodologies and students' personalities.*

Keywords: digital interactivity, foreign languages, technology tools, digital literacy, students' personalities

INTRODUCTION

The great thing that happens today is the invention of computers, mobiles and other technologies that have facilitated the teaching process and the students' studies. Many Moroccan schools and universities are equipped with different technological devices to meet students' needs. Both learners and teachers take benefit from these tools to integrate in their ways of working in order to improve their productivity.

The teaching of foreign languages, to this generation of learners, creates innovative and adaptable teaching strategies, which can stimulate the construction and exchange of knowledge within and beyond the classroom environment. The learning process should therefore be learner directed, collaborative and negotiated through different social interactions either in a traditional classroom or in a virtual space (Crawford, 1996; Driscoll, 1994 as cited in Campbell, 2003). Besides, students shape the educators' methods of teaching towards using more technology. Digital interactivity has mediated the teaching and learning processes, and has also improved students' levels of studies by shaping their ways of working to make connection with people (Dillon, 2004; Longhurst & Sandage, 2004; Piccoll *et al*, 2001; Williams, 2008).

Digital interactivity has "provided both teachers and learners with an alternative avenue to construct and reconstruct knowledge" (Yang, 2009, as cited in Goodfellow, 2011, p. 12).By means of illustration, virtual interaction boosts students' language knowledge, and enhances many language skills that students unconsciously acquire. This modern way of learning has also introduced learners to new literacies such as digital, media and cooperative literacy (Martin & Madigan, 2006).Besides, the current generation of students is more technologically conscious and brings to the educational institutions "a wide range of life experiences and interests" (Lillis, 2003, p. 192).

Students spend hours interfacing electronic devices in class. Some of the "technology-based" language activities involve memorization, motivation and critical thinking. They are beneficial from two sides: language acquisition and cognitive skills development. The increasing presence of communication technologies, such as blogs, discussion lists, video conferencing, and social media, are highly embraced by students. These new technologies inspire teachers to use innovative and adaptable teaching methods that are more stimulating and appealing to learners. For example, the use of the interactive white board facilitates both the learning and teaching processes. Also, PowerPoint presentations can enhance the effectiveness of teaching and the assimilation of courses. Teachers find that the communicative approach to teaching foreign languages is compatible to fuse with technology communications to create an enjoyable and motivational atmosphere in the learning environment. This implies that "learning is not just about knowledge, but also about motivation, engagement and social interactions" (Dettori, Gianneti, Paiva & Vaz, 2006, p.5).

This study is an attempt to explore the presence of using digital interactivity in language courses in higher education, and to test its impact on boosting students' interests towards the learning of foreign languages. The adoption of this modern way of teaching may lead to better learning outcomes, and to the development of the Moroccan educational system by promoting digital literacy in higher education and helping students develop necessary skills to integrate the job market. The objective of this study is to examine students' perceptions of the contribution and use of digital interactivity in the learning of foreign languages. This research sets some experimental questions to be answered by Moroccan university students. The following research questions will be addressed:

1. How far is digital interactivity beneficial for students in enhancing their foreign language acquisition?

2. To what extent do modern technology tools contribute to the success of the learning process?

This exploratory study raises a hypothesis to be tested, to see if it will be accepted or rejected from the participants' perceptions of the major variables that are digital interactivity and foreign languages learning:

H_1: The use of digital interactivity improves students' learning of foreign languages.

The test of the hypothesis will lead to a clear answer to the research questions and to show the impact of digital interactivity on the language teaching field that might be improved.

1. METHODS

As a teacher researcher, I have a strong feeling that digital interactivity plays a crucial role in teaching foreign languages courses that have the potential to cause very important changes in students' studies and even lives. I am trying to discover that not only the university students, but also the teachers can find the adoption and use of digital interactivity helpful in the educational field.

In this research methodology, a quantitative approach has been applied in which a questionnaire is set to answer some pertinent questions of university students' perspectives towards the subject.

1.1 Research materials and procedures

The e-questionnaire was forwarded to students to get their feedbacks on the treated subject and have their answers of a set of questions that would help in analysing the research questions and testing the hypothesis.

The questionnaire needed to be short and unambiguous. The questions were divided into two sections: personal information and practical questions. The electronic administration of the online questionnaire played an important role in collecting the data as much as students can get via e-mails or social networks of "Google form" link.

While designing questions, there were different ways in setting the questions to give more visibility and clarity to the respondents. As the use of Yes-No questions, that is called dichotomous scale. Also, the use of the Rating Scales of five points which provides to the respondents more than one answer option. Besides, the use of the Likert scale which pinpoints students' positions and points of view that might be even neutral. This scale was presented in the questionnaire in two types: strongly agree, agree, neutral, disagree, strongly disagree. And, it was also used in the questions with the choices of: always, often, sometimes, rarely, never.

1.2 Validity and Reliability

This study attempts to ensure the validity of the instruments and the results through these steps. The instrument was designed on the basis of the theoretical framework adopted in this study and similar measures used in previous research. Efforts were also made to align the instructions and objectives of the questionnaire. Finally, the study included a sample of population which may guarantee the generalization of the findings to a similar population.

1.3 Research Design

This study targets Moroccan higher educational institutions. The research environment deals with various public higher schools and faculties in different fields of studies that teach foreign languages, to have more diversity in points of view and perspectives. A sample of Moroccan university students represents the research population since it is a large group. A questionnaire was designed not only to collect data but also to generalize the findings to the population from which the sample is selected. The number of students' participants is 100. The research participants are 53% of males and 47% of females. They were boys and girls ranging in age from 18 to 25 years old.

1.4 Statistical Measurements Procedures

The online questionnaire has facilitated its administration to a large group of participants and in different Moroccan cities. It has also facilitated the phase of the data collections from the "Google drive". Findings were inserted first into the Microsoft Excel for univariate tests of the questions and setting diagrams, and then they were treated and analysed in the SPSS program. I started with a descriptive analysis to KMO & Bartlett's test, to test the significance of all variables. There were 12 questions; the test rejected three questions that will negatively affect the research results. Then a correlation test was applied on the variables to see if there is a presence of a linear relationship between them. After that a regression analysis was set to see the impact of the independent variable of digital interactivity use on the dependent one of foreign language acquisition.

2. RESULTS

This study explores various aspects of using digital interactivity in supporting students' language studies, in different Moroccan educational institutions, from students' perspectives. It also seeks to demonstrate the impact of using digital devices on learners' foreign languages acquisition.

The Number of the research participants is 100, in which there are 53% of males and 47% of females. There is the participation of different levels of respondents' studies: 39% of bachelor students, 34% of masters, 11% of 2nd year and 16% of 1st year students. Moreover, there are participants from many fields of studies;

as the high rate of participation which is from the students studying Arts/Literature47%, and Economics/Management32% as shown in (figure1).

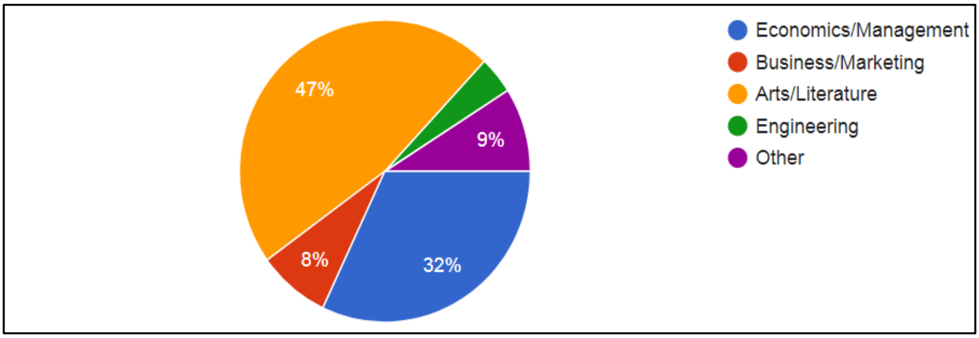


Figure 1. Field of Study
Source: Own work

Almost all respondents positively answer that electronic devices facilitate their foreign language acquisition and help them improve their educational level in higher studies (Figure2).

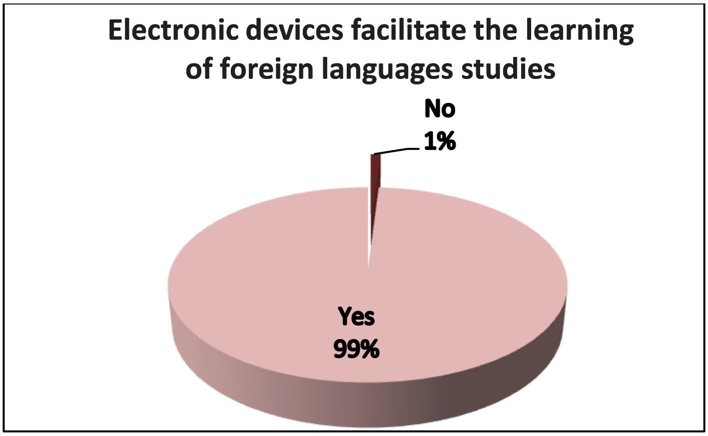
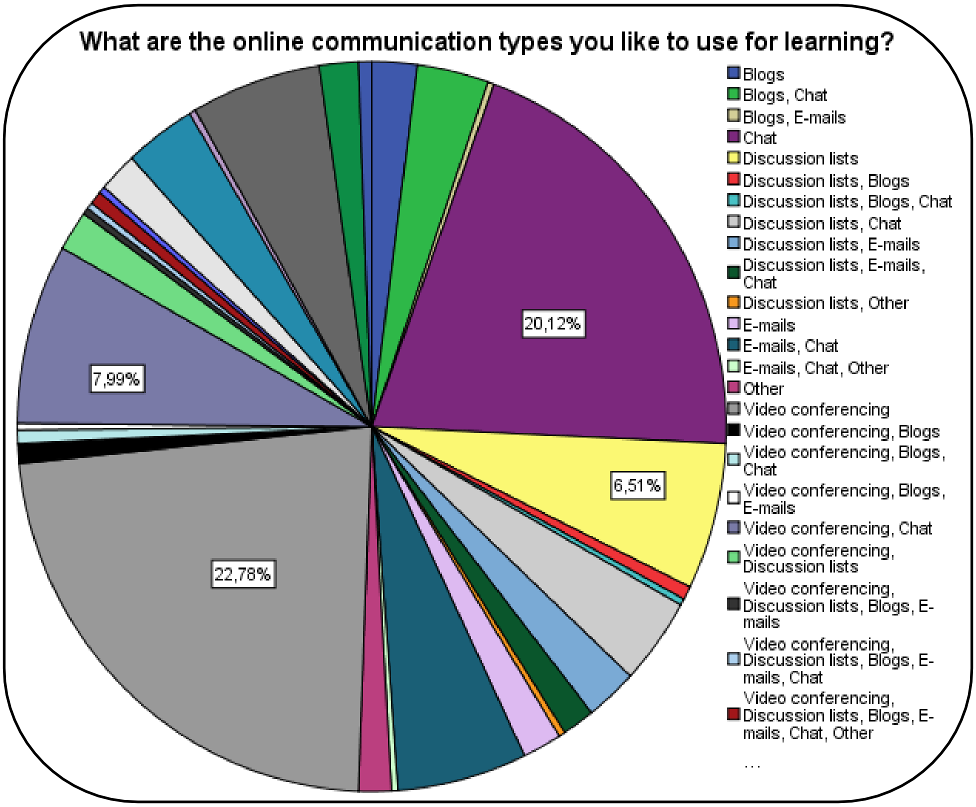


Figure 2. Electronic Devices and Language Acquisition
Source: Own work

According to the results, the preference of students' online communication is mainly interacting via chatting in social networks 66%, they also express their interest towards video conferencing 64% in which they can communicate face-to-face, and also they like commenting in discussion lists 43%. (Figure3).

According to the results, students find the language courses that use technology devices interesting 82%, motivating 66%, and no one finds it boring or unclear. Moreover, participants rank the teaching quality of language studies using technology as good 58%, developed 39%, 29% respondents think it also needs some improvement but no one finds it outdated, as shown in Figure 4. In addition to that respondents confirm that e-learning has an important place in complementing their language learning, and 75% link the course success to the adoption of e-devices as it facilitates the assimilation of language learning courses.

Figure 3. Online Communication



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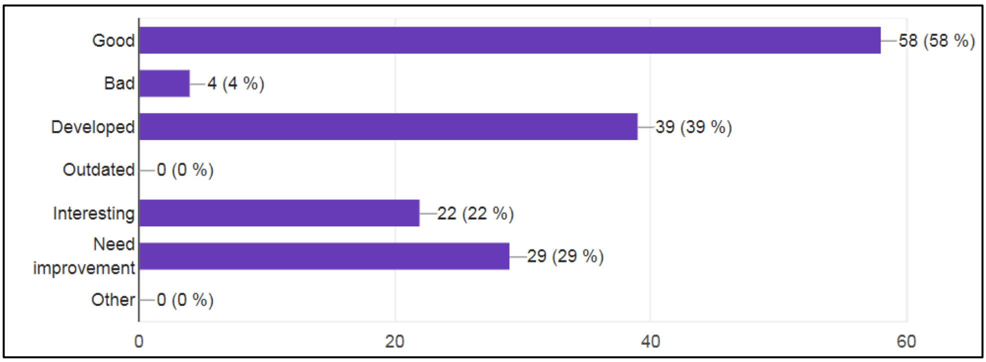

Figure 4. Teaching with Technology Use

Source: Own work

However, using technology devices in classrooms put the frequency of students' communication under a threat. Since, some participants 14% declare that they do not frequently communicate in the language course that uses technology tools and some of them 11% are never engaged in "technology-based" communication activities. But more than 50% of the participants confirm that they do communicate in class with the use of digital devices (Figure5).

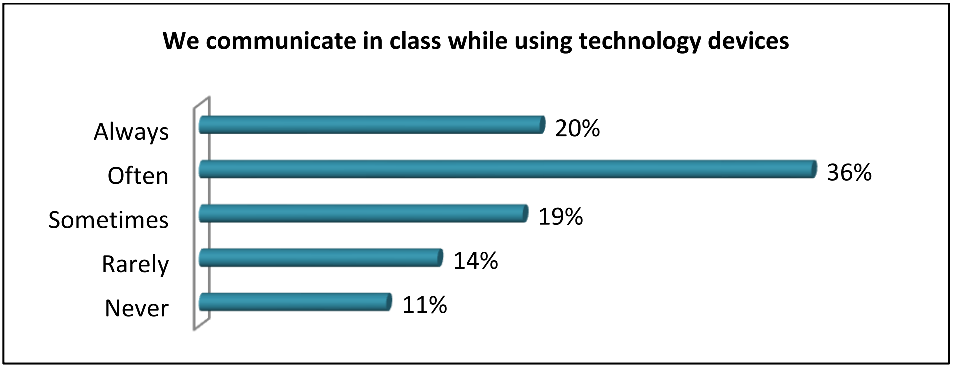

Figure 5. Communication and Technology
Source: Own work

Some of the respondents (60%) state that they were not offered programs to boost their computer skills, and they lack the necessary skills to cope with the language courses' challenges that use technology. Most respondents (95%) are asked to prepare and present projects and works that need a certain mastery of technology devices use. But 30% of the respondents find that the "technology-based" activities are frustrating (Figure 6).

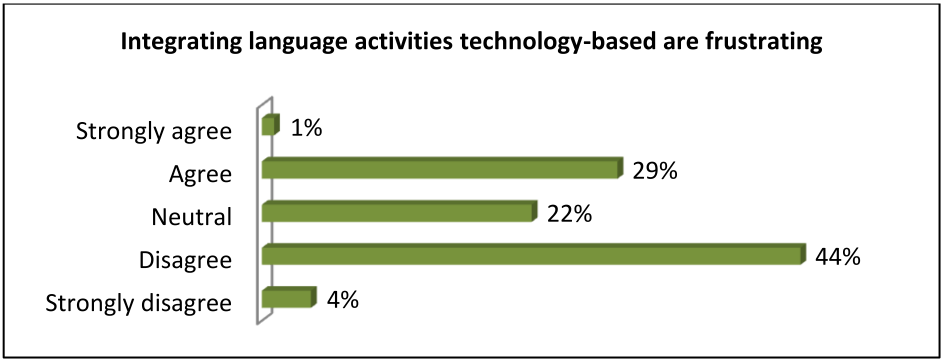

Figure 6. The Fear of Using Digital Devices
Source: Own work

As we can see 52% are for adopting digital interactivity within the communication course, and 20% of the students strongly agree on this point. The rest (17%) assure that they are neither for nor against, maybe because they fear technology. (Figure7)

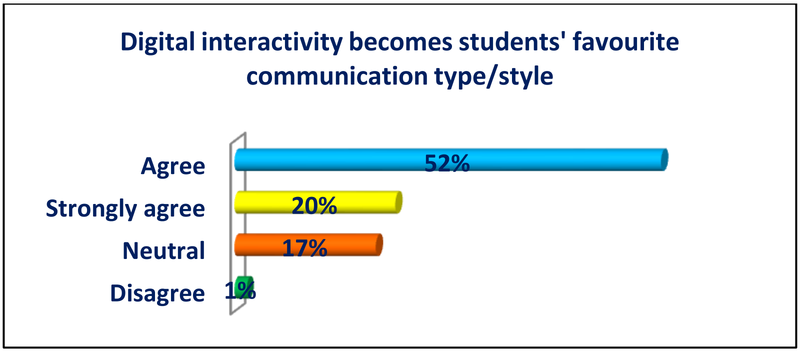

Figure 7. Digital Interactivity
Source: Own work

The variables were statistically significant through KMO & Bartlett's Test. Chi-Square statistic is required to tell us how likely the chosen elements are compatible. And the significance is 0.000 means the questions are valid (Table1).

Table 1.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,492
Bartlett's Test of Sphericity	Approx. Chi-Square	330,195
	Df	78
	Sig.	,000

Source: Own work

The relationship between the two major variables digital interactivity and language acquisition is significant. The correlation is statistically significant 0.000 in all columns. The Pearson correlation value is 0.385 which is a significant value that varies between -1 and +1. This also means that there is a linear relationship between the variables (Table 2).

Table 2.

Correlations

		[The use of Digital Interactivity]	[Foreign language skills development]
[The use of Digital Interactivity]	Pearson Correlation	1	,385**
	Sig. (2-tailed)		,000
	N	100	100
	Pearson Correlation	,385**	1

[Foreign language skills development]	Sig. (2-tailed)	,000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Own work

A regression test was proposed to identify how foreign languages' acquisition is impacted by the use of digital interactivity, the ANOVA test is significant, it is inferior to≤ 0.05 (Table 3), which implies that there is a positive relationship between the two main variables and the impact of digital interactivity on the language development exists.

Table 3.

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	7,122	1	7,122	17,007	,000[b]
1	Residual	41,038	98	,419		
	Total	48,160	99			

a. Dependent Variable: [Foreign language skills development.]

b. Predictors: (Constant), [The use of Digital Interactivity.]

Source: Own work

The regression equation is valid. The predictor variable which is the use of digital interactivity positively impacts of 14.8% the development of foreign language skills.

Table 4.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,385[a]	,148	,139	,647

a. Predictors: (Constant), [The use of Digital Interactivity]

Source: Own work

3. DISCUSSION

This study is an attempt to explore the presence and impact of integrating digital interactivity in learning foreign languages. Students are eager to learn foreign languages courses in a developed way that is full of motivation, interest and happiness in the classroom environment. Digital interactivity is a modern trend of learning and increasing the attention of students towards many language features. According to research findings, students enjoy the use of technology tools inside and outside the class, and as Junghun & Leem (2011) who presented the key features of mobile learning that facilitates the mobility of learning space, flexible access to resources, and the simplicity of study details and interactivity.

Learners then are more attracted towards the course when teachers use electronic devices to help them understand, and give some visual support to what they present and explain. Educators invest in such developed techniques to increase students' learning productivity. Moreover, they take benefit of digital interactions to target students' language acquisition and their personal skills' development as becoming active, update and engaged in the learning process.

This paper proposes a hypothesis that was accepted in data analysis, and which confirms that the use of digital interactivity in the learning process impacts students' foreign language acquisition in a low percentage of 14%.This means that digital interactivity is one of the factors that positively impacts the teaching of foreign languages, and which can be adopted to teaching methodologies. The research results reveal how important the digital interactivity is in students' lives. Thanks to the adoption of this modern method "Digital Interactivity", both students and teachers contribute to the success of the educational process. Hence, learners become interested and motivated to learn foreign languages in a safe e-environment and create a blended learning style that favours the use of digital devices support.

Digital interactivity is a modern model of teaching that has provided educators with the opportunity to blend different strategies in the same learning space. Teachers use a communicative approach to teaching foreign languages and meet students' expectations of developing communication skills using technology. For instance, the use of computers in writing e-mails connects students with teachers in sending work and receiving assignments especially if students are living far from the school in rural areas. In this regard, both Valk and Elder (2010, as cited in Boyinbode & Fasunon, 2015) showed that those students have an easy access to educational materials and information thanks to mobile devices and their services; and which boosts learners' writing skills that some students fear. Besides, students' responses show their interest in using video conferencing to shorten the distance and feel the eye contact, which enhances their observing, listening and speaking skills. In virtual interactions both students and educators promote "greater cognitive flexibility" (Wolfe, 2001, p. 6).

In this study some students express their interest in the use of discussion lists to interact, share opinions and improve their sense of analysis. For some social learning theorists there are mental technology-based activities that enhance the cognitive development of learners. Moreover, students bring to the class new experiences, views and life interest. They contribute to the omission of traditional approaches of teaching, and leave the ground for more constructivist learning environment (Shana, 2009, p. 215). The increasing presence of "web technologies" such as "Blogs, Facebook, Skype… WhatsApp" has triggered teachers to be more open to make use of and adopt a digital interactivity approach to teaching, to motivate students to interact in a less embarrassing and socially oriented atmosphere. Thus, digital technologies favour the sharing of knowledge in the learning environment; by providing numerous opportunities for "exchanging knowledge" (Lea & Street, 1998, p. 157).

However, there is a considerable percentage of students (30%) who are frustrated with technology-based activities. They start to lose interest and attention while using technology devices in classrooms, especially when they feel that they are overtaken. That is to say, they develop certain incapacity to cope with the courses' challenges, since they do not master the required skills to deal with digital devices within or beyond the class. They also expect the teachers to supervise them while using these kinds of activities. For example, students' knowledge of using the interactive whiteboard is limited, to the ones who had an experience in special training. Sometimes, teachers take it for granted that all students know how to handle such e-devices and to further levels.

In addition, students are faced with some challenging projects and presentations in language classes that need a mastery of certain techniques and programs of digital presentation technologies, such as "PowerPoint and Prezi" that most of them just e-learn, 27% of the participants in this study assure that they have never benefited from a program, workshop that could enlighten their interaction with digital devices. Hence, this may have the opposite effect to students' learning outcomes. So, they become passive in group discussions, do not take part in interactive activities and then lose interest in the course itself and maybe in other courses. This does not support the idea off favouring depersonalization of learning that encourages the shy students to participate in classroom discussions (Maier & Warren, 2000; Martin & Madigan, 2006).

Many researchers have recently affirmed that students' engagement with language learning tasks using technology highly correlate with the success of the learning process. Digital interactivity has begun to characterize the work of some teachers but others still avoid this kind of methodology, maybe because of students' frustrations towards technology, the lack of computer literacy support programs or because the classrooms are still not well equipped. There are inherent problems that need to be addressed, like the lack of communication in the language classroom while using technology devices and the students' need to overcome the educational obstacle of digital literacy. Finally, there are other factors that impact language learning to be considered that might be raised in further studies, with a larger sample in terms of population and institutions for more in-depth exploration and more consistent results.

CONCLUSION

Teaching in higher education is always under frequent changes to meet the globalized world's challenges, and respond to every generation's expectations. This paper presents a new trend to teaching foreign languages to Moroccan university students. Digital interactivity is adopted by teachers to create innovative teaching methodologies for better learning outcomes. This study finds out a significant correlation between foreign languages' acquisition and the use of digital devices. Students are conscious of the importance of integrating such technology in their higher studies, and expect teachers to satisfy their interests. Language technology-based activities stimulate students' reflective thinking skills, and enhance their personal skills as becoming active and sociable in the daily interactions. The work revealed an absence of digital literacy programmes for university students, which forms an obstacle in developing their language and communication skills. This research is a contribution to the teaching field to harness the benefits of integrating digital interactivity in education.

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EVALUATION OF MATHEMATICS E-BOOKS FROM THE STEM STANDPOINT

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Abstract: *Current research findings imply that e-learning, curricula, educational objectives and e-books should be aligned with the STEM approach to ensure correct implementation of STEM strategies. The use of ICT is recommended to make e-learning compatible with the STEM perspective in education. In this study, it is aimed to evaluate the integration of ICT and STEM perspectives through assessing middle school mathematics e-books. Middle school mathematics e-books approved by the Ministry of Education in Turkey are examined from the STEM standpoint. The findings of the study are discussed, and some recommendations are given.*

Keywords: STEM Education, E-learning, ICT, Mathematics Education

INTRODUCTION

In learning and teaching, e-learning has an important role in improving the quality of education. ICT recommended for the integration of e-learning with the education system. One of the contents that is the source of e-learning with using ICT is e-books. ICT is the abbreviation of information and communication technologies that are indispensable part of today's educational tools. ICT gives opportunities to individuals in order to have appropriate education in accordance with their readiness and needs. In this way, equal chance for everyone might be fulfilled. With ICT individuals can easily access all kinds of information they need about education. Therefore, the use of ICT is important for each individual to have an easy access to information and a wealth of opportunities in education (Yıldız & Usluel 2016). But sometimes the use of ICT can become a goal, not a tool. Therefore, in order to use these technologies correctly in education and to integrate to the education system, portals are created, and educational contents have been loading. ICT components used in teaching information make this virtual environment suitable for e-learning. Due to the importance of ICT at the centre of education, educators concentrated on specializing in this area (Noskova, Pavlova & Yakovleva 2018).

E-learning offers individuals the opportunity to learn and develop themselves in an environment of their choice and within the appropriate time frame. Consequently, developing e-contents is becoming an important issue. The contents include videos, e-books, educational interactive games, manipulations. These e-contents are being kept up-to-date.

E-books are the most well-known e-contents that provide information in a regular planned way to make learning efficient. Due to cost and easiness of access, e-books save time and are shared by people all over the world so that they make learning diverse and meaningful by enlarging the boundaries of the educational environment. E-books are content related to e-learning. E-books also make it easier to learn about preferred trends and innovations in education at any time and at different locations. The methods and techniques used in learning and teaching are expected to be up-to-date and to meet the needs of individuals, so countries follow the latest trends and approaches in their educational policies. Since e-books have valuable potential in success of these polices, their features need to be assessed.

One of the latest innovative approaches in education is the popular trend called STEM (Science, Technology, Engineering and Mathematics), which aims to make education more productive with a realistic point of view and unites the scientific fields. STEM is an approach that aims to enable individuals of all levels to understand realistic problems and to produce useful, target-oriented solutions to these problems from an interdisciplinary perspective that combines science, technology, engineering and mathematics (Altunel, 2018). STEM is increasingly being adopted and internalized. Because STEM aims to make learning meaningful and to acquire the skills that individuals need in real life with an interdisciplinary understanding, it is getting attention of policy makers. According to Morrison (2006), STEM adopts a more transdisciplinary understanding rather than an interdisciplinary approach due to its integrative structure.

STEM's interdisciplinary structure connects information and makes learning in education focused and meaningful (Smith & Karr-Kidwell, 2000; Fitzallen, 2015). According to Yıldırım and Altun (2015), STEM is a type of education that prioritizes quality and effective learning and aims to help students construct knowledge in life-based areas by supporting high-level thinking skills. Teachers' points of view are as important as the needs of students in STEM. According to the STEM report (MEB, 2016), 91.97% of teachers think that it is necessary to adopt the STEM approach which requires questioning in education. According to this report, the majority of the participants (95.54%)

believe that the lesson activities and programs should be integrated according to STEM principles. This situation reveals the importance and necessity of carrying out our research. On the other hand, OECD (2017) stated that the employment of innovative societies adopting this understanding in STEM fields will increase success of students in workplace. This claim is also supported by different researchers (Lantz, 2009; Turner, 2013). Therefore, STEM can be considered an approach that will contribute to development not only in education but also in all areas of society in the long term. As TÜSİAD (2017) stated, in order to produce and implement practical solutions in STEM fields and to respond to the requirements of innovation, it is necessary to have an innovative, inquisitive and technological perspective. From this point of view, the tools at the centre of the training carried out in order to have the necessary skills should be aligned with the mentioned approach. Since e-books have a significant role in the use of ICT, it is important to evaluate the suitability of e-books that support the STEM approach. The principles and skills on which the STEM perspective is based are important. Aybat (2015) lists these principles and skills:

1- STEM lessons are based on real life issues and problems.
2- STEM lessons guide engineering design steps.
3- STEM engages students in an applied inquiry and open-ended research.
4- In STEM classes, students take part in a productive teamwork.
5- In STEM classes, students apply the math and science content they have learned.
6- STEM allows multiple correct answers and sees it as part of learning to reconsider the error.

E-books that are effective in e-learning should be examined not only in terms of STEM principles but also according to the skills that this approach aims to develop. 21st Century Learning Partnership (P21) is an international organization created to bring the education experts, teachers and leaders in the business life together by providing the necessary support in education, while defining the knowledge and skills that individuals need (P21, 2019). These skills have been confirmed by many studies and described by P21 (2018). These skills are defined as Critical Thinking, Communication, Collaboration and Creativity with the 4C abbreviation. Within the framework of this approach, all STEM areas should be carefully considered and combined to develop targeted skills.

Within the STEM fields, mathematics is both compelling and remarkable because of its content and depth (Becker & Park, 2014; Schmidt & Houang, 2007; Fitzallen, 2015). Mathematics forms the basis of this approach since it is a common language that unites STEM fields (Schmidt ve Houang, 2007; Fitzallen, 2015). Therefore, according to Shaughnessy (2013), if mathematics is not considered within STEM education, this approach cannot develop the language, so interaction between them cannot be achieved and becomes meaningless. When STEM fields are linked to mathematics education, problem solving, and literacy are added to these skills. The question then arises: How can mathematics education align with STEM? Mathematical modelling and realistic problems based on modelling come into prominence in ensuring the compatibility of mathematics education with the STEM perspective. In order to reach the principles and skills determined within this scope, e-learning contents may be arranged within the scope of mathematics education. According to the STEM report (MEB, 2016), necessary ICT materials can be provided to ensure compliance with this approach, interactive board, tablet and EBA portal can be used in accordance with the STEM principles, and most importantly, efforts can be made to bring the e-content included in the EBA portal into STEM. Education Informatics Network (EBA) "Turkey's Social Education Platform" is an online and interactive platform created to raise awareness of sharing information among teachers (Yılmaz, 2013). For this reason, it is important to find means to combine EBA with STEM approach.

In this study, the appropriateness of middle school mathematics e-books was evaluated which are parts of EBA and are an important component for the success of the STEM approach. Although there are many studies related to STEM, the relation of ICT and e-books are not investigated at middle school level.

1. METHOD

1.1 Research Design

In this study, since it was aimed to reveal the status of e-books used in secondary school mathematics education according to the STEM perspective, content analysis was conducted using a qualitative research method. In qualitative research, the process of acquiring data means more than acquiring various data (Creswell 2017). Since the design of the research will be examined in depth and the contents of the e-books will be revealed, a case study is created. Case study is a qualitative research approach in which various data are examined in depth and the existence of themes related to the situation is investigated (Creswell 2007).

In this research, eight e-books which constitute the centre of e-learning in secondary school mathematics education were examined. STEM approaches are taken into consideration while examining those books. Document analysis was implemented.

1.2 Research Sample

Middle school mathematics e-books in Education Informatics Network (EBA) are analysed. These books are approved by the Ministry of National Education. Suitability of these e-books with STEM approaches was assessed. Eight books on four different levels which are sources of e-learning in middle school mathematics were included in the research. Among these books, two of them were for the 5th grade, three of them were for the 6th grade, one of them was for the 7th grade, and two of them were for the 8th grade. These books were examined according to the basic principles of STEM. At the same time, it has been investigated how much it contributes to the development of critical thinking, problem solving, communication, literacy, collaboration, creativity skills required by the 21st century.

1.3 Research Procedures

The findings were compared with the results of STEM reports and workshops conducted within the scope of international studies and attention was paid to similar and different aspects. The findings are compared with different studies (Altunel 2018; Fitzallen 2015; MEB 2016; Aybat 2015; Çakıroğlu & Dedebaş 2018; PWC CEO SURVEY 2016; TÜSİAD 2017; OECD 2017). Within the scope of these principles, instructional contents in e-books were examined. These principles are as follows:

1. Being appropriate to the readiness of students and responding to their needs.
2. Compliance of problem situations with the principle of open-ended research questions.
3. Being consistent with STEM fields.
4. Compliance with engineering-based design, including teamwork, testing and evaluating ideas and approaches of individuals.
5. Reflecting mathematics topics in depth.
6. Being able to be connected to technology and suitable for developing coding and algorithms.

Furthermore, according to P21 (2018), the 21st century skills targeted by STEM education were also examined through sub-themes created by the actions in e-books (e.g. review, search, model, explain) and the main themes obtained by coding them. The frequencies of the themes are grouped and presented in figures.

1.4 Data Analysis

The actions included in the e-books were listed and grouped according to skills. In the next stage, the frequencies of these actions were investigated and analysed at for all grades. The consistency of the findings of the research with the data obtained was checked by a mathematics education specialist and the reliability of the study was ensured.

2. RESULTS AND DISCUSSION

The e-books for each grade used in middle school mathematics education are explained in detail in terms of compliance with STEM principles. In the e-books, explanations that lead to the development of STEM skills are examined through actions. The frequency of actions taking place in e-books is presented in Table 1.

Table 1.

Data on 21st century STEM skills in e-books.

STEM Skills	Themes	5th Grade	6th Grade	7th Grade	8th Grade
Criticical Thinking-Problem Solving Patterns	"Evaluate" "Discuss" "Apply" "Guess" "Solve"	934	1525	422	564
Communication-Literacy Patterns	"Examine" "Search" "Explain" "Say" "Comment"	173	331	120	50
Collaboration-Patterns	"Create" "Produce"	229	369	198	119
Creativity patterns	"Modelling" "Design"	173	120	51	12

Source: Own work

According to the data in the table which can be interpreted that the actions that lead to critical thinking and problem solving are used more frequently and there are very few actions that improve creativity skills at all levels. In PWC CEO Surveys covering many countries, the skills are examined, and it is seen that the problem-solving skill are given the most important one. According to the results of the global PWC CEO research, the rate of difficulty and creativity skills is 77% globally (TÜSİAD, 2017). This difficulty rate in Turkey is 84% and assessed as “very hard” and “hard” (TÜSİAD, 2017).

2.1 5th Grade Mathematics E-Books

Two different e-books were examined for this grade. E-books for this grade begin with some informations and questions to measure students' preliminary knowledge and determine their readiness levels. For example, in the field of number learning, individuals were asked about the geometric shapes that make up patterns on the architectural structures they see in daily lives. The fact that these shapes are formed in an order by drawing attention to how they are formed depends on the association with the concept of pattern. In the next step, 2, 5,8,11 are given numbers with equal differences between them and they are asked to form pattern rule by counting back and forth. At the next stage, by giving shape patterns, they are asked to establish a relationship with numbers and find the rule that forms the pattern. At the last stage, there are activities for the development of reverse thinking and modelling skills by asking them to estimate the number of patterns by missing and to form the models that make up this pattern. These activities have been linked to other disciplines. For example, information about the Turkey Basketball Federation is given and some questions related to this information is asked. From a STEM perspective, information should be linked to realistic life situations (Yıldırım 2018). Problems based on mathematical modelling in the books, the data is presented in a complex way. The use of tables or graphs to interpret the problem situation is limited. Reading paragraphs describing the problem situations are kept short. There are two or three questions related these paragraphs. After the information given in the reading paragraph, mathematics related questions are formed by establishing a relationship with mathematics. There are similar questions that guide individuals to think critically: “*If Yavuz had calculated 500 instead of 534 boxes and 20 eggs instead of 25, what difference would there be between the actual value and the estimate?*”.

“*Why is zero added or deleted when practically multiplying or dividing with the number 10 and its multiples*?”, “*If you are a policy maker for the government, what could be your research problem to start with*?”. The expressions mentioned are indicative of problem solving. It leads individuals to think and question with open-ended questions such as “*what can be?*” and “*why is it like this?*”.

The number of activities requiring group work among students is limited. One of them is given in Figure 1.

Build Millions!

Materials: Colored cardboard, scissors, jars.

- ✓ *Cut the colored cardboard into small pieces with scissors and write down the numbers 1-10 and add to the jar.*
- ✓ *Each of the six people you selected create a number by pulling a number from the jar.*
- ✓ *Include another person in this group takes number to write to the left of the generated number.*
- ✓ *Is it possible to read the resulting number? How many digits?*

Figure 1. Example of Group Activity from E-Book
Source: Own work

There is no activity involving engineering design applications of the STEM approach. Although reading paragraphs are combined with other science, technology and engineering knowledge from other STEM fields, they are lacking in creating new ideas, modelling, prototyping and guiding new product creation. Determined STEM skills in the e-books are analysed and given in Figure 2.

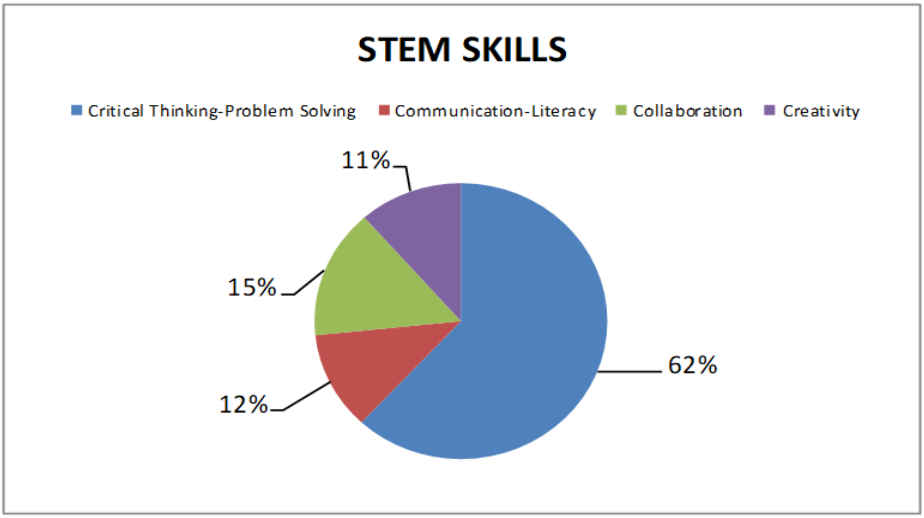

Figure 2. STEM Skills in 5th Grade E-Books
Source: Own work

When e-books are analysed in terms of STEM skills, they use a language that encourages critical thinking and problem solving in order to solve the problems at hand. Different chapters require literacy skills. For example, "Research-Think: Let's research scientists who influence their contributions to mathematics by doing research on natural numbers". However, it can be said that e-books for this grade are lacking in planning activities or actions for engineering education from integrated STEM fields.

2.2 6^{th} Grade Mathematics E-Books

Three different e-books were examined for this grade. Although appropriate information is given related to daily life situations, many problem situations are not suitable for the structure of mathematical modelling which enables integration of STEM. For example, the question, "*In hospitals, priority is given to the elderly, children and pregnant women. So, what is the priority of operations in mathematical situations?*", aims to test readiness of students, but it does not lead to any mathematical modelling. There are some questions that measure reading comprehension. For example, "*Seda wants to make cakes and goes to market. She buys flour, yogurt, milk, eggs and cocoa, chocolate. Which ones will you need when making cakes?*". Problems encourage students to question their knowledge with open-ended questions with words like "How" and" Why".

The STEM approach requires to combine and to relate scientific and mathematical content with technology (Bryan, Moore, Johnson & Roehrig 2015; Çakıroğlu & Dedebaş 2018). Findings indicate that there are no activities involving engineering design.

Although one of the three books is more intertwined with science education, there are no questions that measure the information targeted by science. There are mostly questions that ask for use of critical thinking through games (see Figure 3).

GAME

• Seven friends share the cards created according to certain rules that are related to division of numbers.
• The numbers on these cards are added to a bag by writing and read by a person.
•The person who reads all numbers according to the drawn numbers wins the game.

Figure 3. Example of Game from E-Book
Source: Own work

Determined STEM skills in the e-books are analysed and given in Figure 4.

There is a similarity between the 5^{th} and 6^{th} grades as far as the critical thinking is concerned.

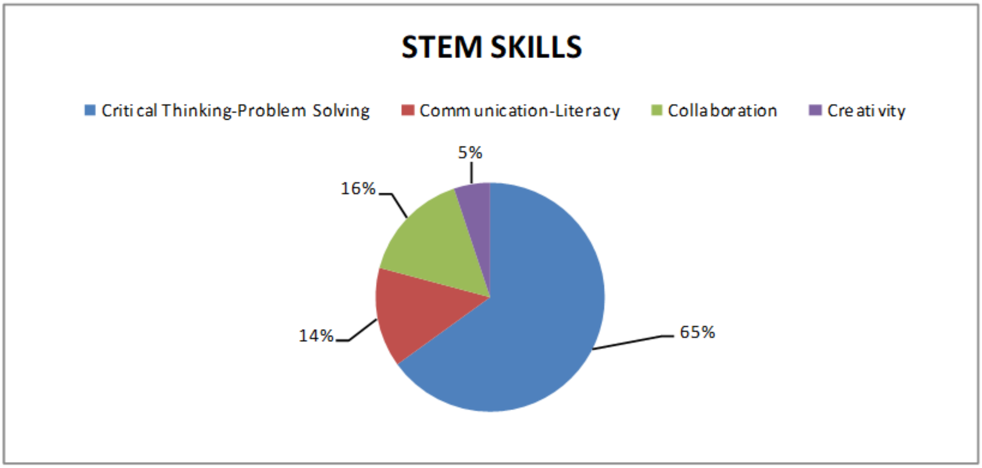

Figure 4. STEM Skills In 6th Grade E-Books
Source: Own work

2.3 7th Grade Mathematics E-Books

One e-book was examined for this grade. Problem situations are associated with real-life situations, but it is not appropriate to produce creative solutions because problems are strictly structured. Mathematical modelling defines daily life situations as the use of mathematics to solve in unstructured problems (Galbraith & Clotworthy, 1990; Ural, 2018). Two examples of these type of questions are as follows: "*If Selim's ratio of the amount of money he paid to the potatoes he bought from the market to the mass of the potatoes was 20/4 ₺ / kg, what could be the price of one kg of potatoes*?", "*In mine area, 8m excavations were carried out every day and the work was completed in 10 days. At the end of this period, how much depth has been descended?*".

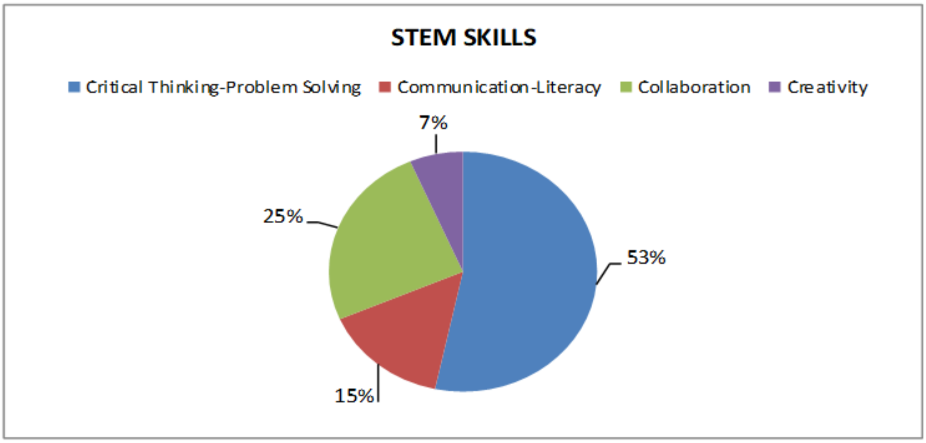

Figure 5. STEM skills in 7th grade e-books
Source: Own work

Immediately after the problem is given, mathematical questions are posed, and answers or solutions are expected. Some activities require teamwork but don't have potential of original solutions.

It is found that there are no connections with science curriculum. There is a limited number of questions that require estimation. The activities are aimed at measuring knowledge and skills on the subject and but not at asking for integration of different subject areas.

Determined STEM skills in the e-books are analysed and given in Figure 5.

Based on the findings, it can be concluded that communication-literacy skills are given more priority if they are compared to other three skills.

2.4 8th Grade Mathematics E-Books

Two different e-books were examined for this grade. Topics starts with realistic problems and these problems support STEM approaches. The contents of these activities are associated with engineering, science, astronomical and medical sciences. In addition, topics are presented with brief notes in order to stimulate prior knowledge of students.

It is found that there are no questions regarding the objectives of science curriculum, whereas there are open-ended which improve critical thinking and problem solving skills questions such as "How" and "Why" related to mathematics (e.g. "*Discuss with your friends how edge and angle information is used in drawing the triangle*.", "*Why is the area of the rectangle formed when the segmented circle shape is joined by opening is equal to the area of the circle? Can you tell that?*")

Some activities include group work but are not called teamwork. Group work is not intended to create a new product but to create new ideas by discussing. Therefore, it would be appropriate to evaluate these studies within the scope of problem solving. Parts of the "project" in the e-book may be considered more appropriate for modelling and STEM, but there are only two project activities. In these projects, groups of four or five students are required. For the projects, groups are formed to carry out the project such as implement, report and present. Such sections are not suitable for engineering-based design and can be interpreted as lacking the development of creative skills. When students make mistakes, there are no guiding instructions. The aim is to gain knowledge not to integrate different fields. The lack of questions that characterize aiming to measure the objectives of science and other STEM areas is another aspect of these e-books that needs to be developed.

Determined STEM skills in the e-books are analysed and given in Figure 6. In one of the two books examined, there are sections in the Geogebra program that allow you to observe the geometry issues with tasks related to the use of ICT for mathematics teaching. In another technology related section, there are questions that guide students to research on technology and to think about the relationship between mathematics education and technology. One of these questions is: "*Which number's exponents are used in the coding process in information technologies? Investigate and think*". Determined STEM skills in the e-books are analysed and given in Figure 6.

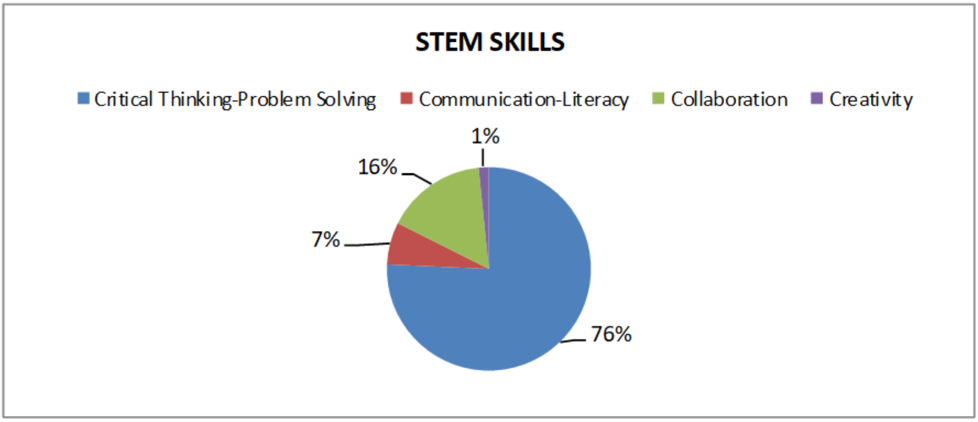

Figure 6. STEM skills in 8th grade e-books
Source: Own work

According to the findings, more action is used to improve the students' critical thinking skills and problem-solving skills in mathematics education. There are few or no activities to improve their creativity.

CONCLUSION

E-books are one of sources of e-learning. E-books have a potential of integrating ICT in the educational settings. E-books should be a real guide in students' knowledge formation through supporting STEM skills required by workforce. It is important to evaluate the relevance of e-books that provide integration between education and ICT to the STEM approach in terms of its role in teaching. The STEM approach has an important place in today's education. This study provides findings that take e-books into consideration from the STEM standpoint. According to the findings, presenting the mathematical contents in accordance with the problem-solving steps is not enough to include the engineering-based approach. Due to the negative attitude towards engineering, students should be given engineering and design education from an early year and on (Yıldırım 2018). The contents of e-books should be rearranged so that new ideas and new solutions developed after problem solving give an opportunity to produce new products. According to Çakıroğlu & Dedebaş (2018), in-class activities and contents applied in teaching may require a different approach when examined from the perspective of STEM. Problem solving and critical thinking skills were prioritized in the e-books, but they are inadequate for projects involving teamwork and have no content to improve creativity.

Due to its suitability to the STEM approach, mathematical modelling activities should be taken into consideration in mathematics education (Çakıroğlu & Dedebaş, 2018). Although it varies according to grade levels, it is observed that realistic life problems in the e-book for the 6th grade don't support modelling and are lack of relationship with science education or other STEM fields (except mathematics). The need to understand mathematics in daily life situations and to use the information learned in the context of mathematics education in real life will be increasingly effective today (NCTM, 1989; Ural, 2018). The fact that the frequency of 'solve' and 'guess' actions come into prominence in the e-books does not mean that students do not need other skills. Considering that the contents of the e-book are organized according to the curriculum, STEM should be considered the only area by combining the aims of these fields. Placing the reading texts related to STEM fields at the beginning of the topics in e-books does not mean that they are integrating different fields in STEM. Immediately after these reading passages, questions about mathematical operations or mathematical issues leave STEM literacy skills in the background.

RECOMMENDATIONS

Based on the findings and conclusions of the study, following recommendations can be made:

- Both e-books and curricula, methods, techniques and resources used in educational settings should be aligned with STEM.
- Resources should be aimed to gain STEM skills while aligning with the mentioned educational approach and e-content and programs should use a language that is suitable for this purpose and guide and improve the creativity of individuals.
- While integrating the disciplines, the learning targets in curricula should be handled in accordance with the grade level and rearranged in a unifying manner.
- E-books should be examined in different ways, kept up-to-date and made more useful.
- E-books should be made interesting with rich content.
- Activities in e-books which involve collaboration and creativity can be used to acquire the skills required by the 21st century.
- E-books can be improved by reorganizing in order to support engineering designs.

- E-books should inform individuals about technological applications, not just technological knowledge, and include applications in this field.
- This research has been carried out within the scope of mathematics education in Turkey and therefore it can be examined in different areas in different countries.
- STEM portals can be created to shed light on e-learning.

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CHAPTER III: E-LEARNING IN THE DEVELOPMENT OF KEY AND SOFT COMPETENCES

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THE IMPACT OF EDUCATIONAL TRENDS ON THE DIGITAL COMPETENCE OF STUDENTS IN UKRAINE AND POLAND

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Abstract: *The rapid development of technology is having an effect on the processes of communication and collaboration in society, which requires the transformation of education and training of the citizen of the digital society. This article presents European experience in the transformation of education, in particular an analysis of legislative initiatives in Ukraine and Poland in the field of digital society formation. The authors look at world trends and educational trends which are considered part of the modernization and digitization of the education system of the two countries.*

A survey was carried out, in the international project Erasmus + K2 MoPED, on current educational trends, educational technologies and their impact on the digital competence of students. The study showed a high level of interest among students in the presented educational trends, which shows the need to build students' digital competence. The authors demonstrate the effect of the absence or lack of digital skills on the citizen's overall life chances. The article deals with the influence of the type of intelligence on the learning *process, presents students' new educational needs, highlights innovative pedagogical technologies and methods that will allow us to take into account educational trends and follow the modern requirements for digital transformation of education.*

Keywords: digital competence, educational trends, transformation of education, innovative teaching technologies, digital tools.

INTRODUCTION

Digital technologies are driving global change in our lives – professions are disappearing, people are being replaced by artificial intelligence, and the flow of information is steadily increasing. Technologies have become an important part of our daily lives, they surround the modern man at home, at work, in transportation, on vacation, in education. Due to the rapid development of technologies, there is a change in the processes of communication and cooperation in society. Previous research in this area focused on the phenomenon known as the digital transformation (Henriette, Feki, Boughzala, 2015). The educational system in the information society must be an anticipatory system. The transition from a conservative education system to an advanced one should be based on the formation of an information space corresponding to an e-system, where the student will feel free in the digital space due to the widespread use of information technologies and the introduction of new infrastructure solutions. One of the possible ways to achieve these goals is to digitize the educational process of institutions of higher education, because higher education institutions are the focal points for the design of the latest technologies and serve as a launching pad for innovation, which generally ensures the development of any human activity and promotes socio-economic growth. Digitalization of education means modernizing, reforming and transforming it as well as solving problems and making decisions using digital technologies. Digital technology must be integrated into all areas of education, teacher training, educational infrastructure, methodology (pedagogy), educational resources and leadership management at all levels and in all sectors of the education system (Morze, Vasylenko, Gladun, 2018).

1. TRANSFORMATION OF EDUCATION

The European experience in the transformation of education is the introduction of specific initiatives. The EU digital education system is being implemented within the framework of the EU 2020 Strategy and its leading initiatives: the Digital Agenda for Europe, the Agenda for New Skills and Jobs, and the Innovation Union. In 2015, the European Framework Program for Digital Educational Organizations (Kampylis, Punie, Devine, 2015) was developed and in 2016 the European Platform of Digital Competences for Citizens was updated, which is the framework structure for describing digital competences to be used by business entities and educational institutions in defining directions of training specialists in the modern labour market and determining the content of their training. Digital teaching and learning is also considered within the framework of the strategic programme Education and Training 2020. It addresses the issues of engaging teachers in enhancing their digital competence and how to stimulate this process. All these initiatives contribute to the development of digital competences, lifelong learning on the Internet and opportunities for all; aimed at building an innovative society, an open and secure digital environment; solve cybersecurity problems; contribute to attracting investment in education infrastructure and supporting specific teacher training programmes and upgrading their skills; promote the adoption of new legislation for the Digital Single Market, the European data economy, and the online market.

The article analyses the impact of educational trends on digital competence formation in two countries: Ukraine and Poland.

Analysis of Poland's legislative initiatives to form a digital society.

The current relevance of the article is also determined by numerous national and foreign documents regarding the development of the information society and the knowledge society as well as the related transition to a global competence society in which both global economics and the status of education are changing: Strategy for the computerization of the Republic of Poland - ePoland. Proposed directions of development of the information society in Poland until 2020; A strategy for smart, sustainable and inclusive growth. Communication from the Europe 2020 Commission; Digital Poland OP PC 2014–2020; Digital Agenda for Europe. A Europe 2020 Initiative (2014); Higher education development programme to 2020 and others.

A good example of implementing the university's computerization strategy is the University of Silesia in Katowice. As part of its own activities in the field of science, research, innovation, cooperation, it has launched national and international projects, implemented various initiatives in the use of e-learning in lifelong learning, and taken care of the development of the digital environment. These initiatives bring concrete results at the University of Silesia: The Distance Learning Centre at the University of Silesia (CknO (DLC) US) has its goals, concepts as well as the methodology of implementing e-learning at the University of Silesia. The Centre for Distance Education is a university-wide organizational unit of the University of Silesia, conducting activity in the field of electronic education and the use of internet technologies for this purpose. The Centre's activities include:

- Assistance in creating a distance learning system (SKO) at the University of Silesia, configuration of the e-learning platform made available to University of Silesia units, training and consultations related to its operation.
- Creating an IT infrastructure for SKO.
- Server administration and maintenance.
- Providing SKO resources to units of the University of Silesia.
- Participation in the development, launching and implementation of improvement courses in electronic education studios.
- Technological consultations regarding the organization of work of training centres via the Internet.
- Organization of conferences, workshops and training for SKO users and designers.
- Participation in the work of regional information society centres and in the work of inter-university SKO development units.
- Participation in the implementation of conceptual and implementation projects as part of cooperation with other entities (http://www.cko.us.edu.pl/informacje -o-uprzedce.html).

The university's information strategy is based on a very important state document "Strategy for the development of digital society in Poland until 2013" (http://www.mswia.gov.pl/strategia/), which aims to improve the situation in terms of ability to acquire, gather and use information as a result of dynamic development of information and communication technologies (information and communication technologies - ICT). In addition, the university bases its activity on such strategic documents as "Digital Poland OP PC 2014-2020", "Proposed directions of development of the information society in Poland by 2020". In accordance with the assumptions of the state documents, university strategic documents related to the development of the digital environment were prepared. Some other examples of creating and implementing the information and education environment at partner universities as well as initiatives of the University of Silesia have been described in (Smyrnova-Trybulska, 2018).

Analysis of regulations, laws and agreements signed between Ukraine and the European Union clearly show that the main goals of the information society in Ukraine gradually converged with the vectors of Europe (Morze, Vember, Gladun 2019). One of these very important documents is: the initiative “Digital agenda for Europe”; European economic development strategy “Europe 2020: A strategy for smart, sustainable and inclusive growth”. These documents formed the basis of the Digital Agenda for Ukraine 2020 project, which was presented by the Cabinet of Ministers of Ukraine and defines the main priority positions of building the information society in Ukraine on the basis of integration into the world processes of "digitalization" (Alpakova 2015).

The process of digitalization of facilitating the educational process, makes it more flexible and adapted to the realities of the modern day, which in turn ensures the formation of competitive professionals. In education, digitalization is driving new trends. In the study, the concept of "educational trend" is used for interpretation: changing the direction of educational technology. Educational trends, in turn, directly influence educational technologies as the newest means of achieving educational goals.

The Joint Research Centre European Commission in cooperation with the Institute for Prospective Technological Studies conducted a study "School's Over: Learning Spaces in Europe in 2020: An Imagining Exercise on the Future of Learning". The report examines trends that are divided into several conditional levels - macro, meso and micro (Figure 1).

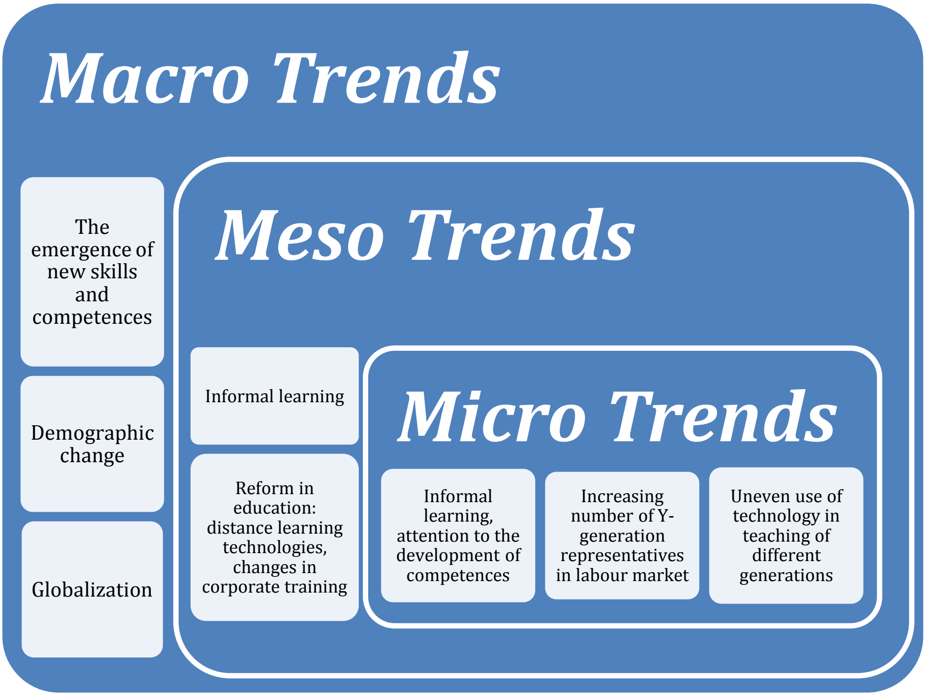

Figure 1. Trend levels
Source: Own work

The impact of new technologies on education is viewed from different angles. The Educause Horizon Report 2019 Higher Education Edition, which was published in April 2019, forecast trends, challenges and development of technologies that affect higher education. In particular, the new trends include:

- Long-Term Trends
  - Rethinking How Institutions Work
  - Modularized and Disaggregated Degrees
- Mid-Term Trends
  - Advancing Cultures of Innovation
  - Growing Focus on Measuring Learning
- Short-Term Trends
  - Redesigning learning spaces
  - Blended Learning Designs

The report describes the significant challenges impeding technology adoption in higher education: Improving Digital Fluency, Increasing Demand for Digital Learning Experience and Instructional Design Expertise, The Evolving Roles of Faculty with Ed Tech Strategies, Achievement Gap, Advancing Digital Equity, Rethinking the Practice of Teaching (Alexander, Ashford-Rowe, et al., 2019).

Taking into account the world and educational trends, which are considered in the framework of updating and digitization of the education system of Poland (https://centrumcyfrowe.pl/wp-content/uploads/2016/10/cyfryzacja-polskiej-edukacji_final_EN.pdf) and Ukraine (National Qualifications Framework https://mon.gov.ua/en/tag/natsionalna-ramka-kvalifikatsiy), the following trends have been identified:

- STEAM-education
- Formation of competences (professional and life competences)
- Personalization of learning, adaptive learning
- Outcome-oriented practice-oriented learning
- Development of entrepreneurial, research and critical thinking
- Gamification
- Development of non-formal education, openness and accessibility of education
- Mobile learning
- Changing the role of the teacher

The survey was conducted within the framework of the international project Erasmus + K2 MoPED (Modernization of pedagogical higher education by innovative teaching instruments MoPED - №586098-EPP-1-2017-1-UA-EPPKA2-CBHE-JP). 2118 students from Polish and Ukrainian universities took part in the survey (63 and 2055 respectively). Students filled out questionnaires asking them to rate the importance of educational trends that directly influence educational technology; whether they are experiencing changes in education approaches; components of digital competence; use of digital tools in training and etc.

Respondents were asked to rate the significance of these trends from 1 to 10 (1 is not important, 10 is very important). The average score for each trend is presented in Figure 2.

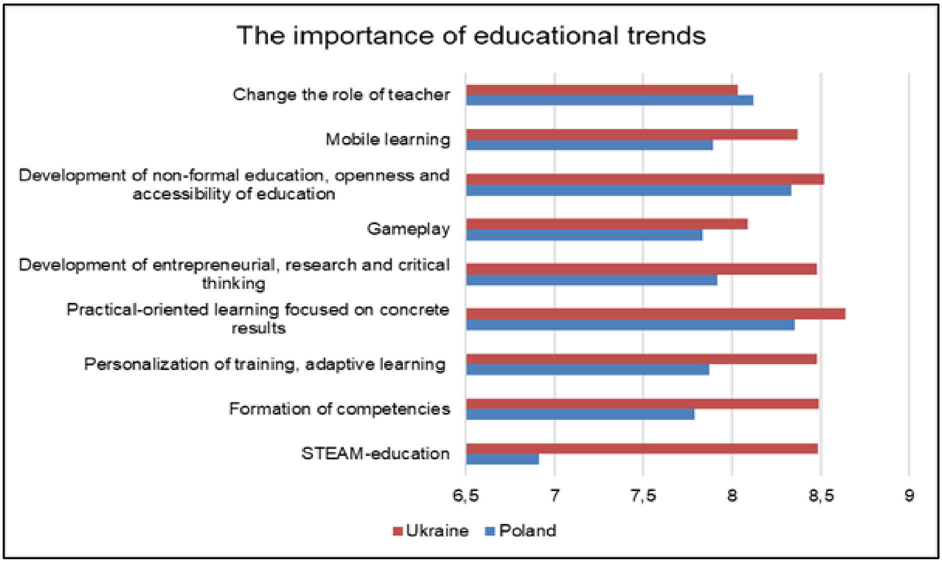

Figure 2. The importance of educational trends for students
Source: Own work

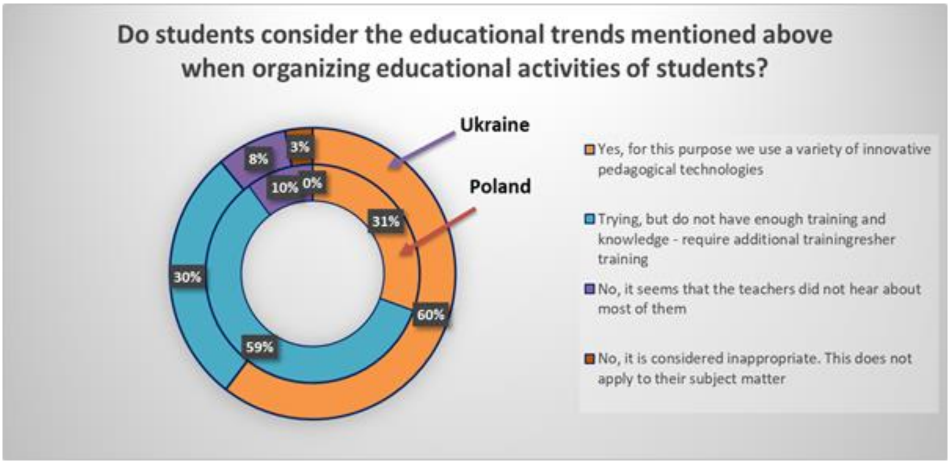

Figure 3. Results of the poll "Do students take into account educational trends?"
Source: Own work

Choosing from the proposed trends, students from Ukraine and Poland highlight the importance of «Practical-oriented learning focused on concrete results» and «Development of non-formal education, openness and accessibility of education». However, there is a gap between students' assessment of some trends; such trends as STEAM-education, formation of competences, development of entrepreneurial, research and critical thinking were considered by students from Ukraine as more important than students from Poland.

It was interesting to compare the views of students from different countries when asked if teachers consider these trends in their professional activities (Figure 3). Particular attention is drawn to a difference in percentage, where teachers are trying to take into account the educational trends - respectively 60.4% (Ukraine) and 31% (Poland), and those that do not take into account trends in education - 3.1% (Ukraine) and 0% (Poland).

2. DIGITAL COMPETENCE. FEATURES OF STUDENTS BASED ON THE THEORY OF GENERATIONS

The study shows the students' high interest in the presented educational trends, the emergence of which has become, in particular, the digitization of society and education. Why is digital competence so important today?

Digital competence is a new concept that describes the skills associated with technology. Several terms have been used to describe digital skills such as ICT skills, technological skills, 21st century skills, information literacy, digital literacy and digital learning skills. These terms are also often used synonymously, including digital competence and digital literacy (Adeyemon, 2009, Krumsvik, 2008).

The DigComp framework is a reference system to support the development of citizens' digital competence in Europe. It describes what competences are needed today to use digital technology in a confident, critical, collaborative and creative way to achieve work, learning, leisure and participation goals in the digital society. Digital competence is recognized by the EU as one of the 8 key competences for a fulfilling life and activity.

Lack of digital skills can have a profound effect on people's overall life chances, competitiveness and ability to work. About 40% of the European Union (EU) population lack digital skills - 22% of them have none at all. These are often elderly, under-educated youth, low-income families and migrants. Moreover, 32% of the EU workforce lack digital skills, and 13% believe they lack digital skills. It should also be noted that across the EU, 42% of citizens who do not have computer skills are inactive in the labour market.

Many citizens lack the opportunity to harness the full potential of digital technology in their daily lives. In addition, there is no common understanding of what digital skills are or how to evaluate them. The problem is also that the students are representatives of the Z-generation, while the representatives of the Y and X generations teach them.

The now popular "Generation Theory" emerged at the intersection of a number of disciplines: economics, demography, history, psychology (Strauss, Howe, 1997). "Z-generation" is a term used in the West for the generation of people born between the 1990s and the 2000s (Tapscott, 2008). Everything that the previous generations called "new technologies" or "technologies of the future" is already present for the Z-generation. Children born in this period are special, they are "others". According to the characteristics of people of the digital generation, Natalia Morze (2013) distinguishes the features of students in the perception of information: rapid response, non-linear approach, giving preference to graphical information, processing information that flows continuously in multiple streams.

The teacher is no longer the bearer of knowledge that (s)he tries to impart to the student. Her /His main task is to motivate students to show initiative and independence. The teacher is becoming an organizer of independent activity where everyone could realize their abilities and interests, create conditions, develop environment in which it becomes possible to develop the personality, to acquire knowledge and skills necessary for life in the digital society. It should be noted that one of the trends in education is that the student should be at the centre of the educational process. The purpose of the teacher is to direct the student, and the purpose of the student is to "create".

The old educational needs are replaced by new ones:

- Standardization - The ability to find creative solutions.
- Agreeableness (consent) - Autonomy with responsibility.
- Centralization - Joint decision making.
- Lecturer - Teamwork.
- Teacher - the only source of knowledge - Ability to find the right sources of information.
- Standard lesson - Using the project method, problem-based, inquiry-based learning, flipped learning using digital resources.
- Knowledge control - Formative assessment.
- The same type of material - Sorting educational materials and tasks by type of multiple intelligence of student (Gladun 2014).

3. EDUCATIONAL TECHNOLOGIES. CHANGES IN LEARNING APPROACHES

Taking into account the peculiarities of the students and the educational trends identified above, innovative pedagogical technologies and methods were highlighted. Their use will allow us to take into account these trends and to follow the modern requirements for digital transformation of education:

- Integrated learning (a combination of several principles of science)
- IBL (Inquiry Based Learning - research studies).
- PBL (Project Based Learning - project method).
- Collaborative learning.
- Flipped classroom.
- Virtual, mixed and augmented reality.
- 3-D printing.
- Technologies for the formation of media literacy.
- Computational thinking.
- Problem-oriented learning.
- Mixed learning.
- Billing (dual) training.
- Peer to peer assessment - assessment equal to each other.
- Make-up - educational technology based on students creating their own hands some products.
- Storytelling - pedagogic technology enables you to transmit various information through storytelling.
- Inclusive Education Technologies.
- Microlearning - The utilization of short educational videos.
- Distance Learning Technologies.
- Technology of formation of critical thinking.
- BYOD (Bring Your Own Device) - using their own technology gadgets.
- Technology of formative assessment.
- Use of e-learning game environments.

The average score of significance of each of the mentioned modern pedagogical technologies for students is presented in Figure 4.

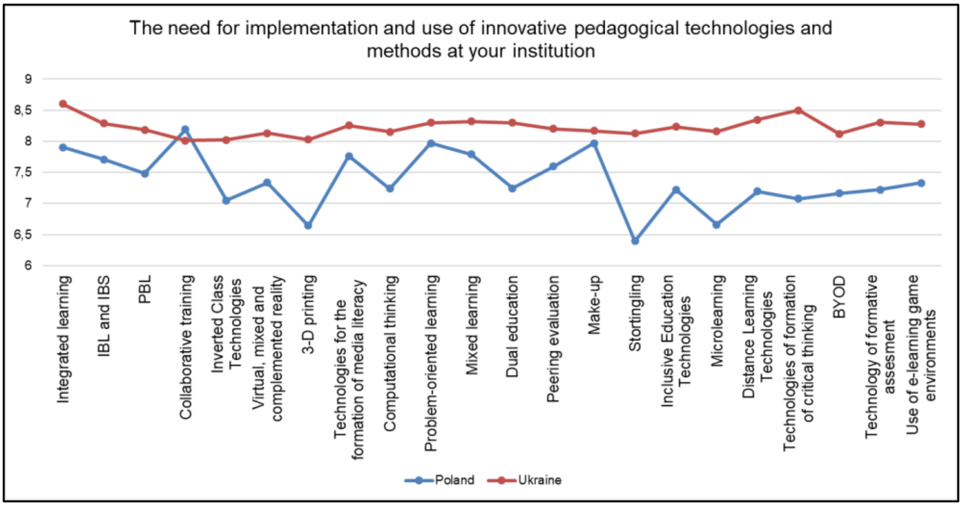

Figure 4. The significance of modern pedagogical innovative technologies for students

Source: Own work

It is worth noting that the Ukrainian students showed strong interest in using the proposed technologies. At the same time, the interest of Polish students is not focused on all technologies, in particular, in the use of technologies such as 3D-printing, Storytelling, Microlearning, Flipped classroom. This may be due to a lack of material resources, such as 3D printing, and a lack of familiarity with the techniques used in the educational process. Particular attention should be paid to the shared interest of students from the two countries in the following technologies: Integrated learning, Collaborative training, Problem-oriented learning, Make-up, which demonstrates the need to change approaches to conducting classes.

The study also determines the level of students' interest in digital tools and their ability to use them effectively in the educational process (Figure 5).

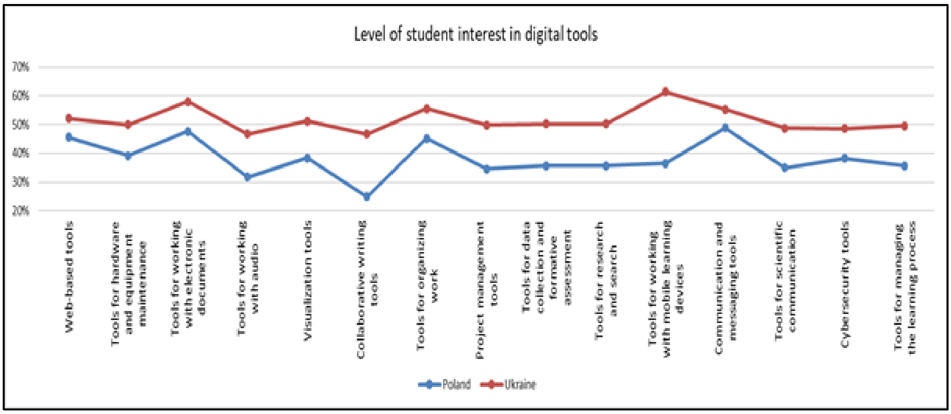

Figure 5. The interest of students to use digital tools

Source: Own work

The results show that the percentage of students interested in Tools for working with audio, Collaborative writing tools are low because they already know how to use them well. But groups such as the digital tools: Web-based tools, Tools for working with electronic documents, Tools for organizing work, Communication and messaging tools require implementation and use in education to improve the quality of training.

The conducted research can serve as a benchmark for changing the approaches to student learning. In particular, the results show a high level of attention to the students' use of digital tools in their training and formation as professionals. Approaches to organizing the educational process should be transformed so that students learn digital tools of the web, work with electronic documents, visualization, research, work with mobile devices for learning, communication and messaging, scientific communication and collaboration in the process of teaching ICT disciplines and immediately practiced using digital resources and digital tools to gain competences: media literacy, digital communication and collaborative responsible using ICT, creating digital content, solving ICT problems while studying all other disciplines. In view of the results of the survey and their analysis, universities should improve work programmes of all disciplines, e-learning courses, focus on more involvement of these tools to achieve the educational goals of the disciplines of practical, professional and general direction.

CONCLUSIONS

The survey confirms and indicates that digital society citizens have access to knowledge that is common but in need of rapid on-demand search, as data is constantly updated by millions of members daily on global Internet sites (Web-based tools). The student should be able to analyse and work with big data (Tools for working with electronic documents). In addition, the growth of social networking technologies has enabled people with similar learning interests to come together as a group to share knowledge about a specific topic that can create a deeper, more intense and immersive learning experience in a community of like-minded people (Communication and messaging tools). The speed of change and multitasking require the student to be multifunctional and organized (Tools for organizing work).

All of these digital learning trends have a dramatic impact on an important segment of the software industry used for corporate learning and the development of an outdated learning management system that does not update and does not address the need for change.

Therefore, further research should be aimed at exploring the necessary plug-ins and updates in the Learning Management System (LMS) to take into account educational trends, student characteristics and students' digital competence.

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ANALYSIS OF STUDENTS' REFLECTIONS ON THEIR EDUCATIONAL BEHAVIOUR STRATEGIES WITHIN AN ELECTRONIC COURSE: DEVELOPMENT OF COMPETENCES FOR THE 21st CENTURY

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Abstract: *The paper describes how students' reflection on their educational behaviour strategies changes within an e-course. The authors suggest that an e-course design and the organisation of students' independent work can influence the development of the 21st century competences. Two profiles of students' educational behaviour during the study process within an e-course can be distinguished: a profile of educational activity and a profile of professionalisation. The focus on professionalisation influences the increase of interest in the learning content, and induces mechanisms of self-regulation and self-management. A student perceives an individual activity as the most comfortable, and associates an e-portfolio with a modern way of professional self-presentation. The focus on educational activities determines the importance of feedback from the teacher, attention to the scores and ratings of educational achievements, as well as the preferences of a group work, where a learner can join in the exchange of experience and demonstrate a creative approach. When designing an e-course, it is advisable to foresee these profiles. The reinforcement of formative assessment techniques support students' self-organisation and initiative as target markers for prospective competences.*

Keywords: educational behaviour, reflection, 21st century competences, e-learning, digital environment, formative assessment.

INTRODUCTION

E-learning and blended learning as modern forms of the educational process occupy an important place in the practices of higher education. In this direction, it is possible to outline global and local factors. One of the global factors is digital economy development. Digital technologies are considered a resource for the development of society, they transform all aspects of human life, leading to significant sociocultural changes. Digital tools transform the nature of human activity: its content, organization, and necessary skills, ensure the new quality of results. This also applies to educational activities. It is necessary to remember about new priority competences that will be required by today's students in their future career and implement in training advanced activity models (in particular information activity models). IFTF (Institute for the Future) presented a future work skills summary map in 2011 (IFTF, 2011). Key skills needed in the future workforce were named there: new media literacy, virtual collaboration, transdisciplinarity, design mindset, and other. In this respect, M. Vinagre described a practical experience of developing teachers' telecollaborative competences (Vinagre, 2017).

In the local Russian context, the Atlas of Emerging Jobs was developed with the participation of the Agency for Social Initiatives and Skolkovo (Atlas of Emerging Jobs, 2015). The Atlas presents professions that should become highly demanded over the next 5-10 years. In the field of education, the presented professions not merely require ICT competences, but they are entirely realised
in the digital environment, for example, digital ethics and safety teacher, designer of consciousness training tools, game educator, educational online platform coordinator, etc. To be in such jobs, a person should possess new professional skills and abilities – inter-sector communication, multilingual and multicultural abilities, and interpersonal skills.

The study "Russia 2025: resetting the talent balance" developed a target competences model for future specialist focusing on cognitive (adaptability, solving non-standard tasks) social behavioural (intercultural interaction, communication) and digital skills.

In accordance with actual educational and professional demands, bachelor and master programmes are logically targeted to the development of the 21st century professional competences. In a situation of uncertainty and a rapid change in the conditions of professional activity, the ability to take an unconventional decision, innovative approach, has become especially important (Pérez-Peñalver et al, 2018). Today we witness "the growth of the creative economy, mass collaboration, participatory culture, and peer production", and this idea is a starting point for constructing learning environments (de Aldecoa, 2015, p. 90). Consequently, in this context, it is interesting to analyse a contribution of specific academic disciplines to this process, to answer a number of practical questions: How does students' reflection on their educational behaviour change in the context of e-learning and blended learning? Can an e-course design and the organisation of students' independent work influence students' understanding of their educational behaviour strategies and form the basis for the development of prospective competences for the digital society?

1. METHODS AND PROCEDURES OF THE STUDY

The study was carried out in the Herzen University (Saint-Petersburg, Russia) during the teaching of the course "Information technology" for first-year bachelor students of "Pedagogical Education" programme. In the process of teaching, distance education technologies were used to facilitate students' autonomous work, because according to the higher education standards in Russia, bachelor students should have up to 40% of autonomous work, supported by assignment guidelines. To support training, an e-course was worked out in LMS Moodle.

As one of the most important features of the course, we can note the enhanced function of formative assessment. The main idea is drawing students' attention to the evaluation of their own educational behaviour in the digital environment. By educational behaviour, we understand a system of actions that a learner undertakes to implement the processes of interaction with the educational content and other participants of the learning process (teachers and peers). This phenomenon is closely connected with creating new knowledge, transmitting and distributing it. Consequently, together with educational behaviour goes informational behaviour. Ohtoshi and Gottschalg- Duque proposed a model of informational behaviour that incorporates its main processes and factors (Ohtoshi and Gottschalg- Duque 2016). Lavrik et al described information behaviour as "human activities aimed at obtaining the necessary information and using it for research, production, training, etc., as well as for creation of new information and its dissemination in society" (Lavrik et al 2018, p. 42).

In order to identify the characteristics of changes in students' perception of their educational behaviour strategies while undertaking an e-course, during the process of receiving this new learning experience, an entrance and a final (reflexive) questionnaire were proposed. In the context of the activity approach to understanding the essence of educational behaviour, three generalised components of educational informational behaviour were identified, as well as their main indicators:

– Motivational component (starting level of knowledge for the educational content, interest, awareness of practical importance of solving educational and professional tasks);

- Activity component (comfort of individual and group work, initiative and creative approach);
- Organisational component (reflection and self-management of educational activities, self-organisation, time-management, orientation to the maximum score, orientation to the position in the rating, orientation to the meaningful reflection (need for feedback), awareness of the importance of the electronic portfolio).

For the analysis, 12 main variables were identified as indicators of students' educational behaviour in the particular learning context, analysed in the paper:

1. ICT skills level.
2. Interest in the educational content.
3. Awareness of practical importance of ICT for solving professional problems.
4. Awareness of practical importance of ICT for solving educational problems.
5. Comfort of individual work.
6. Comfort of group work.
7. Initiative, creativity.
8. Self-organisation, time-management.
9. Orientation to the maximum score.
10. Orientation to the position in the rating.
11. Focus on reflection (need for feedback).
12. Awareness of the electronic portfolio value.

The questions in the questionnaires were formulated in such a way that they affected all three of the listed components of educational behaviour, as well as their main indicators. Table 1 shows the examples of questions.

Table 1.

Examples of questions for the entrance and final questionnaires

	Variables	Entrance questions (Relate to the 5-point scale)	Final questions (Yes/No)
		Motivational component	
1.	ICT skills level.	Your ICT skills level.	Have you improved your ICT skills level?
2.	Interest to the ICT (educational content).	Your interest to the ICT.	Has your interest to the ICT increased?

3.	Awareness of practical importance of educational content for solving professional problems.	The importance of the ICT for your future profession.	Do you plan to use the knowledge gained in the classroom in your upcoming professional activities?
4.	Awareness of practical importance of educational content for solving educational problems.	The importance of the ICT for your learning.	Do you plan to use the knowledge gained in the classroom in your upcoming learning?
		Activity component	
5.	Comfort of individual work.	I usually complete assignments individually.	I was comfortable completing assignments individually.
6.	Comfort of group work,	When doing assignments, I would like to see how other students perform them.	I was comfortable completing assignments in-group.
7.	Initiative and creativity.	When doing assignments, I try to be creative.	I tried to perform additional tasks that required creativity.
		Organisational component	
8.	Self-organisation, time-management.	I try to complete my tasks in time.	I usually completed my tasks in time.
9.	Orientation to the maximum score.	I will regularly monitor my score in the e-gradebook.	I regularly monitored my score in the e-journal.
10.	Orientation to the position in the rating.	It is important for me to see and compare my peers' grades.	I regularly followed my peers' grades accumulation.
11.	Focus on reflection (need for feedback).	The teacher's comments on my assignments are important to me.	Comments and notes in the e-gradebook helped to overcome problems with assignments.
12.	Awareness of the electronic portfolio value.	I consider an e-portfolio a convenient tool.	I liked to keep an e-portfolio of completed assignments.

Source: Own work

It is important to note that the entrance questionnaire was more of a projective nature from a psychological point of view, because the students only started to study the new course and could rather assume their future behavioural features in the process of learning. In the final questionnaire, they responded, having already concrete results, showing self-esteem and reflection of the experience gained. In total, 200 respondents took part in the survey. Answers of the respondents were analysed in several directions: a statistical analysis of the entrance and final questionnaires was made (cluster analysis and correlation analysis), and the percentage indicators of positive answers were compared for the selected variables of the two response arrays.

2. ANALYSIS OF STUDENTS' REFLECTION ON THEIR EDUCATIONAL BEHAVIOUR STRATEGIES WITHIN AN ELECTRONIC COURSE

2.1. Results of the entrance questionnaire

Figure 1 shows the results of the cluster analysis of the responses received during the entrance questioning.

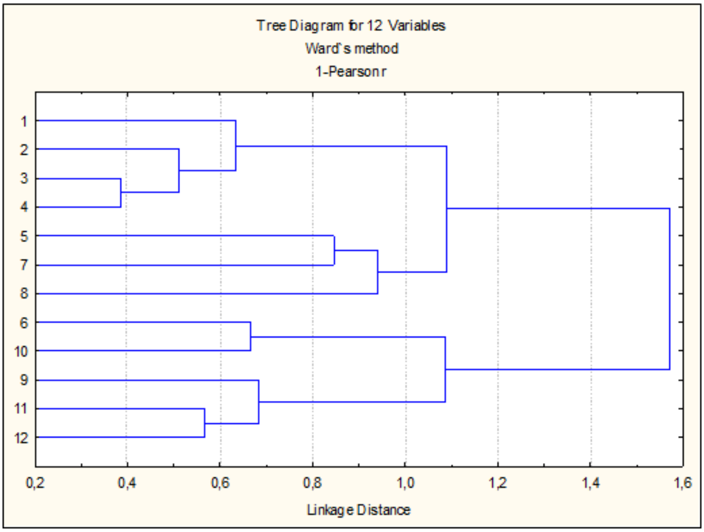

Figure 1. Cluster analysis of the entrance questionnaire results

Source: Own work

We can distinguish three clusters in Figure 1. The first cluster is formed by variables V1 (ICT skills level), V2 (Interest in the ICT), V3 (Awareness of practical importance of educational content for solving professional problems), V4 (Awareness of practical importance of educational content for solving educational problems). Consequently, this cluster fully includes all selected indicators of the motivational component of informational behaviour. Correlation analysis showed that the closest correlations were found between V3 and V4 —

awareness of the practical significance of the material being studied in solving educational and professional problems (r = 0.61).

Consequently, according to students' answers we can conclude that there is a need to strengthen professionally oriented and practically oriented types of activities for learners. It is necessary to mention that this idea finds support in the new generation of educational standards in Russia.

In addition, it is possible to make a conclusion about the need to form competences that ensure the conscious approach to self-education. For this purpose, a system of formative assesment techniques and tools was incoporated to the course. Firstly, a system of questionnaires was developed for students. Together with the entrance and final questioning, each of the topics was accompanied by short reflexive poll (often with the use of mobile technologies) that prompted students to evaluate their progress and to think about possible reasons for difficulties and incomprehension. Secondly, interactive tasks of the same reflexive nature were offered for some of the topics, for example, interactive Venn diagrams where it was necessary to mark the ratio of assimilated and undigested material. Thirdly, each task was provided with criterial rubricks for self-evaluation that helped students to understand to what extent it is necessary to complete the task to get the maximum and minimum score. Fourthly, the course was provided with an e-gradebook, where teachers could not only mark a student's assignment with a certain number of points, but also add comments to explain the reasons of the assigned marks. Finally, it is important that each student was gathering an e-portfolio of all works during the course. All e-portfolios were open to the teacher, and each student could decide whether to open it to peers or not. We can note that most of the students preferred an open e-portfolio, and in the final questionnaire, they admitted that it was very beneficial for their own progress to follow the advancement of other students, to compare completed assignments.

The second cluster comprises variables V5 (Comfort of individual work), V7 (Initiative and creativity), V8 (Self-organisation, time-management). The formation of such cluster leads to the conclusion that it is necessary to take special account of the needs and volitional characteristics of students who seek to work independently, who are sufficiently self-organised and focused on the enrichment of opportunities for solving educational tasks with a reflexive feedback.

However, the range of answers on these variables is quite large and the correlations between these variables are relatively weak (r = 0.15). This shows that students do not attach much importance to the nature of their actions. Teachers need to focus attention on this. It is necessary for the development of reflexive competences (Bondarenko, 2019) that helps students to "to become critical formers of their working life and teaching" (Kaiser 2018, p. 191).

The third cluster includes variables V6 (Comfort of group work), V9 (Orientation to the maximum score), V10 (Orientation to a position in the rating), V11 (Focus on reflection, need for feedback), V12 (Awareness of the electronic portfolio value).

The merger of variables V9, V11 and V12 suggests that students seeking to achieve high marks associate the evaluated results with the understanding of what has been achieved, with the ability to systematise and demonstrate the learning results by means of an e-portfolio. A correlation was found between variables V6 and V10 ($r = 0.33$), which confirms the need for evaluating individual achievements in group work. Probably, some students view grouping as an integration of efforts in pursuit of a measured result.

Thus, according to the results of the entrance questionnaire, a "model" collective, rather diverse student's profile was obtained, based on students' anticipation of educational behaviour, past experience in learning activities, as well as a slightly idealised "image" of themselves in the context of solving educational problems. A student, who has a high-level motivational component of educational behaviour, is sufficiently knowledgeable of the material being studied and is interested in further improvement. He is aware of the practical significance of the content being studied both in educational and in future professional activities. He is ready to work individually, be creative and systematically organise own activities. In group work, he focuses on the maximum score and position in the overall rating, as well as appreciates feedback from the teacher and is interested in accumulating his work in the format of an electronic portfolio. Consequently, the achievement of the described features of educational behaviour is possible if such "model" benchmarks are incorporated into an e-course during its design.

2.2. Results of the final questionnaire

Figure 2 presents the results of a cluster analysis of the responses received as a result of the final survey.

Here, the situation is significantly different from the entrance questionnaire and reflects the real situation of students' reflection on their educational behaviour. We can distinguish two clusters. The first cluster is formed by variables V1 (ICT skills level), V12 (Awareness of the importance of the electronic portfolio), V2 (Interest to the ICT), V8 (Self-organisation, time-management), V3 (Awareness of practical importance of educational content for solving professional problems), V5 (Comfort of individual work). This agglomeration suggests that for many students during the learning process supported by an electronic course, interest in the field of information technology was the catalyst for the development of competences that ensure the level of ICT skills. It is important that interest be combined with self-organisation, to support which a number of formative assessment techniques were used in the electronic course.

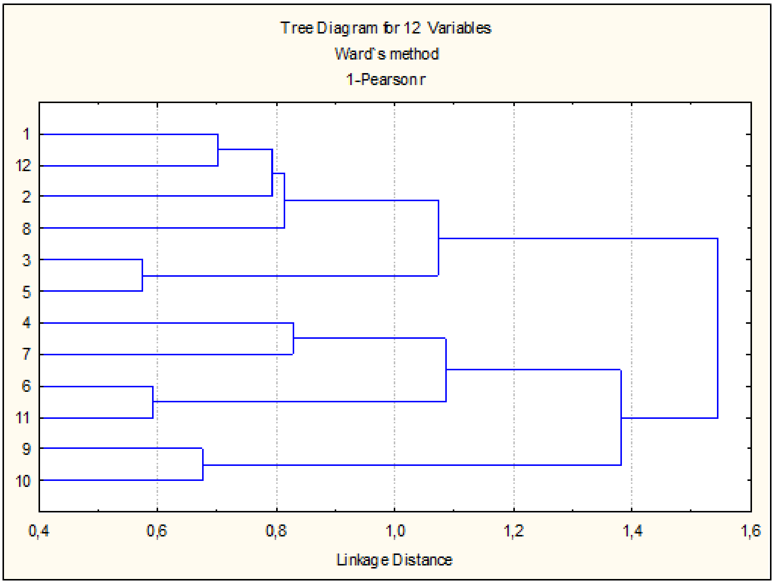

Figure 2. Cluster analysis of the final questionnaire results

Source: Own work

Variable V3 (Awareness of practical importance of educational content for solving professional problems) can be considered the most significant; it precisely correlates with the variables V1 (r = 0.42), V2 (r = 0.36), V5 (r = 0.42), and V12 (r = 0.34). This is an important outcome of the course, because along with the development of important general cultural competences that ensure human actions in the modern information environment, the task of forming the future professional position of the teacher was considered very meaningful.

The second cluster includes variables V4 (Awareness of practical importance of ICT for solving educational problems), V7 (Initiative, creativity), V6 (Comfort of group work), V11 (Focus on reflection), V9 (Orientation to the maximum score), and V10 (Orientation to the position in the rating). This cluster shows that students in practice experienced a variety of possibilities of receiving feedback while mastering the course. It is important to note that students associate the provided opportunities for group work in the network mode (V6) with the empowerment of meaningful reflection (V11) (r = 0.4). Thus, for many learners, their peers' feedback was effective. The actions and the results of others made it possible to understand better their own actions and achievements.

Variable V9 (orientation to the maximum score) has a rather significant correlation with variable V10 (orientation to the position in the rating) (r = 0.32). Thus, students confirmed that the current scoring, an open e-gradebook, for many students contributed both to a steady advancement and to striving for timely correction of results.

Interestingly, variable V6 has a correlation with variable V12 (r = 0.38), although they belong to different clusters. This link demonstrates an awareness of the e-portfolio effectiveness for presenting the process and the results of group work. This is an important result, since for many students it was the first experience in solving educational problems in the mode of distributed networking. They tested in practice an important technique of continuous reflexive assessment, which they can apply to further training and upcoming professional activities.

According to the two described clusters, two profiles of students' educational behaviour during the study process within this e-course can be distinguished: a profile of educational activity and a profile of professionalisation.

The focus on professionalisation influences the increase of interest in the material under study, and induces mechanisms of self-regulation and self-management. In such a situation, a student perceives an individual activity as the most comfortable, and associates an e-portfolio with a modern way of self-presentation (including professional self-presentation) in the digital environment. This strategy can be named as a "model of personalised individual activity" (Laptev 2013). Here, in the situation of solving the tasks of the upcoming professional activity, a whole range of important competences are developed, including ICT competences and self-organising competences. However, the most important thing is that the development of professionally significant personal qualities are stimulated.

The focus on solving problems primarily of educational activities determines the importance of feedback from the teacher, attention to the scores and ratings of educational achievements, as well as the preferences of group work, where a learner can join in the exchange of experience, discussions, and can demonstrate initiative and a creative approach. Such an activity strategy can be called a "model of distributed educational activity" (Laptev 2013). In such a situation, students, by joining forces and distributing tasks among themselves, achieve high results in a short period.

From all described above, we can conclude that when designing an e-course, along with the described "model" benchmarks, it is advisable to provide different levels of mastering the material. A "profile of educational activity" should be designed as basic and mandatory and a "profile of professionalization" - as an extended and an in-depth route for those who are interested in a more detailed acquisition of the study material for solving future professional tasks.

2.3. Comparison of the results of the entrance and final questionnaires

Further, we present a comparison of the entrance and final questionnaires for students in terms of a number of selected positive answers (Figure 3).

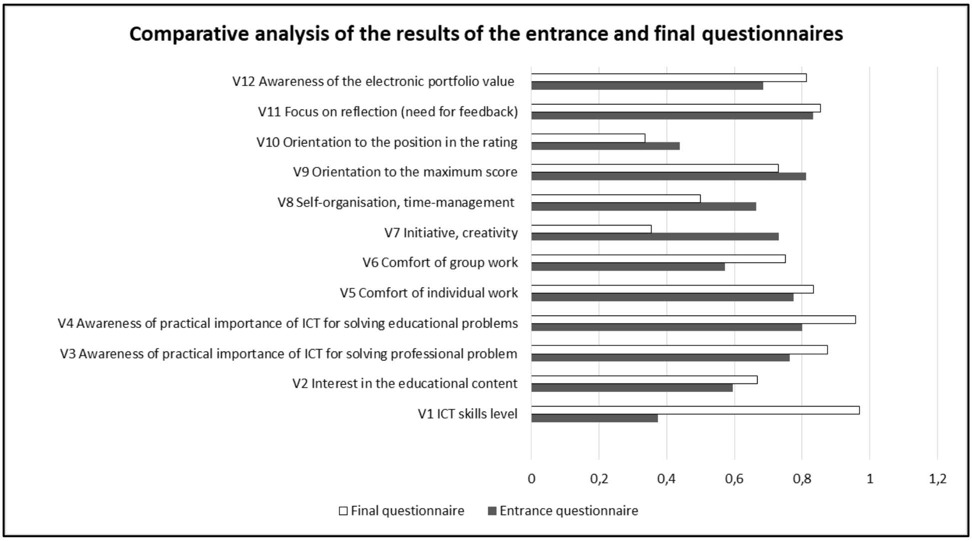

Figure 3. Comparative analysis of the results of the entrance and final questionnaires

Source: Own work

Figure 3 shows that differences in the responses of students at the initial and final stages of training were found. Most of the variables of the motivational component increased their values. The greatest change is characteristic of the variable V1 (ICT skills level), which is natural, since students took part in a targeted training. At the same time, we see changes of the values for the variable V7 (Initiative, creativity) of the activity component and the variables V8 (Self-organisation, time-management), V9 (Orientation to the maximum score), V 10 (Orientation to the position in the rating), and V11 (Focus on reflection) of the organisational component. This can be explained by several reasons. At the beginning of their studies, students could overestimate their abilities (for example, from the point of view of self-organisation). But the feedback they received when studying the course helped them to reflect on this. In addition, in the course of training, priorities could change (for example, the focus on the maximum score was replaced by the satisfaction of the average score due to the complexity of tasks or low interest in specific tasks).

The positive changes reflected in the diagram indicate a certain interrelated transformation of informational and educational behavior of students, which occurred due to motivational, diagnostic, organizational, and controlling methods implemented in the e-course. The e-portfolio allowed students to be creative in mastering the discipline and to try out in practice models of learning interaction in the digital environment. It is important that students could choose comfortable individual or group forms of information activities.

CONCLUSION

The study described in the paper, proves that students' perception of their educational behaviour changes in the situation of e-learning and blended learning. The vector of these changes largely depends on an e-course design. A significant role in this context play purposefully organised conditions for students' reflection, as well as formative assessment technology. Among the effective tools for formative assessment can be suggested reflexive polls, an e-gradebook, a rating of learning scores, peer assessment, a feedback from the teacher and peers, and an e-portfolio.

At the beginning of a course, students have an idealised model of their behaviour. Consequently, it is advisable to incorporate such "model" benchmarks into an e-course during its design. However, prospective competences for the digital society demand variability and personalisation of learning experiences. In this prospective, a profile of educational activity and a profile of professionalisation can be offered. In the course of study, the possibility of implementing different educational profiles of a student, depending on abilities, preferences, and experience may be provided. This approach is accordant to the adaptive learning ideas.

The data analysis described in the paper, shows that the greatest risks of e-learning and blended learning from students' educational behaviour point of view are related to the organisational component (self-management): learners find it difficult to manage time. This might be the reason for choosing easier assignments that do not require creativity, the lack of aspiration to receive a high score and be in the top-list of learners. This problem is quite frequent and is confirmed by numerous similar studies in this field. Thus, Nkhoma et al, with the use of learning analytics within e-courses, detected poor time-management as one of the main reasons of academic failure (Nkhoma, 2019). One of the ways of solving this problem is the reinforcement of formative assessment techniques that support students' self-organisation and initiative as target markers for prospective competences development.

The future steps of the study involve students' online activities analysis in LMS Moodle with the use of learning analytics methods. That will give an opportunity to compare the changes in students' thinking and reflection with the objective behavioural changes that occur within an e-course.

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COMPUTATIONAL THINKING: MOTIVATION TO LEARN IN TERTIARY EDUCATION

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Abstract: *The paper presents an educational case study – investigation of motivation towards learning computing and computational thinking in tertiary education. In the first part of the paper background of the study is presented – why it was necessary to try to measure motivation. The second part describes the three motivation surveys known in the literature - Motivated Strategies for Learning Questionnaire (MSLQ), Academic Motivation Scale (AMS) and Model of Academic Motivation Inventory MUSIC. The next part describes a survey in which the Model of Academic Motivation Inventory was used. Statistical results of MUSIC Inventory are presented and answers to one of the five open-ended questions are discussed. Preliminary cluster analysis is performed which is the part of ongoing research. Final remarks include an open question – is it possible to increase students' motivation and, if it is, how to do this?*

Keywords: motivation, learning, computing, computational thinking.

INTRODUCTION

Teaching Applied Computer Science Course (Computing and Computational Thinking Course) dedicated to students not specialized in informatics (Gajewski, Wlasak, & Jaczewski, 2013) is a very big challenge. All multimedia materials (Gajewski, 2016b), flipped classroom technology (Gajewski & Jaczewski, 2014) and the automatic flowcharting tool (Gajewski, 2018) used in this course did not improve the quality of learning and learning outcomes and caused cheating problems (Gajewski, 2016a). Lack of motivation towards studying Computer Science among students could be the main reason of this situation. In order to help to design a course that more engages students in learning a survey of academic motivation was prepared and conducted.

1. COMPUTING AND COMPUTATIONAL THINKING COURSE

The Applied Computer Science course at the Faculty of Civil Engineering at Warsaw University of Technology was presented in many previous papers. It was mainly based on a book (Dale & Lewis, 2015). Last year there was a shift towards Computing and Computational Thinking in Civil Engineering as presented in books (Riley & Hunt, 2014) and (Wang, 2015). Much more attention and stress were put on such problems as logic, solving problems, modelling solutions, algorithmic thinking and data organization.

Computer labs are divided into three blocks. The first one called first things first (three weeks) is devoted to basic things like file systems and file transfer and effective use of a text processor. The second block, also three weeks long, is devoted to spreadsheet. There are three major points in this block: logical functions and conditional statements, database functions and their usage and Solver. The third block leads towards algorithmic thinking and programming and is devoted to Computer Algebra System Mathcad. The first part of Mathcad classes is devoted to solving classical mathematical problems: symbolic calculations, definition of variables and functions, calculus (integrals, derivatives, limits), matrix and vector operators and functions, solving problems (linear and nonlinear equations, minimization and maximization). The second part is devoted to simple programming, not object-oriented as it was suggested many years ago (Gajewski, 1994), (Gajewski & Lompies, 1996).

2. ABOUT MOTIVATION

Motivation refers to “the reasons underlying behaviour” (Guay et al., 2010). Broussard and Garrison (Broussard & Garrison, 2004) broadly define motivation as “the attribute that moves us to do or not to do something”. Researchers often contrast intrinsic motivation with extrinsic motivation, which is governed by reinforcement possibilities. Educators believe intrinsic motivation to be more desirable and to result in better learning outcomes than extrinsic motivation. More publications about motivation can be found in a report with literature review (Lai, 2011) and in a book about motivation for learning and performance (Hoffman, 2015).

2.1 Motivated Strategies for Learning Questionnaire MSLQ

Prior to Motivated Strategies for Learning Questionnaire (MSQL) a lot of research on student learning focused on differences in learning styles. The idea of individualized learning styles became popular in the 1970s and has greatly influenced education despite the criticism that the idea has received from some researchers (Coffield, Moseley, Hall, & Ecclestone, 2004). Theoretical background of MSQL is an adoption of a general expectancy-value model of motivation (Eccles, 1983). The first model created by Pintrich (Pintrich, 1988) proposes three motivational components: an expectancy component, a value component and an affective component. The first tool for assessing students' motivation beliefs and self-regulated learning strategies consisted of 44 questions (Pintrich & De Groot, 1990). They were used to form the following five scales: self-efficacy, intrinsic value, test anxiety, cognitive strategy uses and self-regulation. The final version of MSLQ (Pintrich, 1991) has 81 questions divided, like the first version, into two parts: motivation scales and learning strategies scales. The first part consists of six scales: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning & performance and test anxiety. The second part consists of nine scales: rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time/study environmental management, effort regulation, peer learning, and help seeking. Reliability and predictive validity of the motivated strategies for learning questionnaire was later studied in (Pintrich, Smith, Garcia, & McKeachie, 1993). A validity and reliability study of the motivated strategies for learning questionnaire was presented in (Ilker, Arslam, & Demirhan, 2014). Review of MSLQ using reliability generalization techniques to assess scale reliability was presented in (Taylor, 2012).

Motivated Strategies for Learning Questionnaire was later used by many researchers. The making of MSLQ was presented in (Duncan & McKeachie, 2005) and review of MSLQ in (Artino Jr, 2005). This questionnaire was used in assessing motivation and learning strategies of generation 1.5 Korean immigrant students (Stoffa, Kush, & Heo, 2011). The MSLQ was also used to score validity among medicine residents (Cook, Thompson, & Thomas, 2011).

2.2 Academic Motivation Scale AMS

This measure of motivation towards education has been developed in French as Echelle de Motivation en Education (EME) (Vallerand, Blais, Briere, & Pelletier, 1989). The EME was composed of 28 items subdivided into seven scales. They assess three types of intrinsic motivation - intrinsic motivation to know, to accomplish things and to experience stimulation, three types of extrinsic motivation – external, introjected and identified regulation and amotivation. Some years later EME was translated into English through appropriate methodological procedures and renamed to Academic Motivation Scale (AMS) (Vallerand et al., 1992), (Vallerand et al., 1993).

AMS is still in use. Cokley examined the validity of AMS by comparing scale construction to a self-determination theory (Cokley, 2000) and later performed psychometric investigation of AMS using a United States sample (Cokley, Bernard, Cunningham, & Motoike, 2001). Fairchild evaluated existing and new validity evidence for AMS (Fairchild, Horst, Finney, & Barron, 2005). Hegarty applied AMS to graduate school students (Hegarty, 2010). Kusurkar investigated validity evidence for the measurement of the strength of motivation for a medical school (Kusurkar, Croiset, Kruitwagen, & ten Cate, 2011). Haslofça examined reliability and validity of AMS for the sports high school students (Haslofça & Korkmaz, 2016). Zhang performed revision and validation of AMS in China (Zhang, Li, Li, Li, & Zhang, 2016).

2.3 Model of Academic Motivation Inventory MUSIC®

The MUSIC® Model of Academic Motivation Inventory (MUSIC® Inventory) is a questionnaire that can be used by instructors and researchers to assess students' perceptions of the MUSIC components for an activity or course. The MUSIC Inventory is a research-based questionnaire that has been shown to produce valid scores. The inventory was developed by Jones to measure constructs related to the five primary components of the MUSIC Model of Academic Motivation (Jones, 2009). More details of the MUSIC® Model of Motivation can be found in Jones' book (Jones, 2017). Validity evidence for the MUSIC Inventory was presented in (Jones & Skaggs, 2016) and other publications – for the elementary school version in (Jones & Sigmon, 2016), for pharmacy students in (Pace, Ham, Poole, & Wahaib, 2016), for Chinese and Spanish speaking university students in (Jones, Li, & Cruz, 2017) and for students of science in Iceland in (Jones, Sahbaz, Schram, & Chittum, 2017).

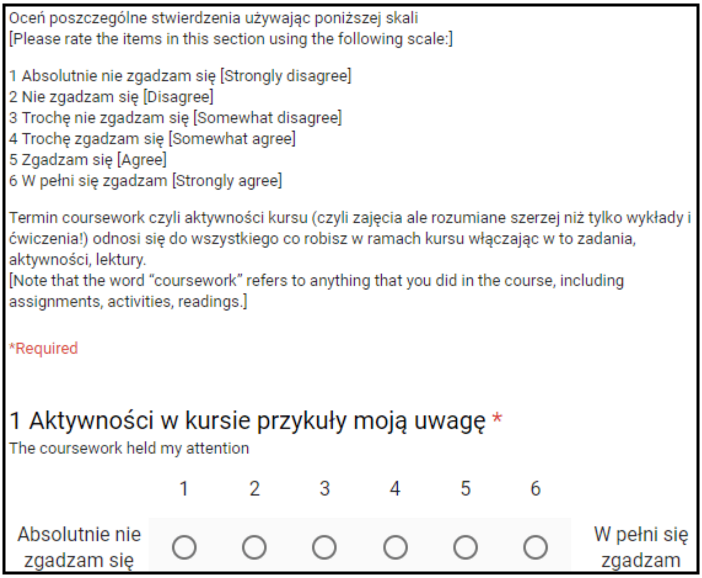
The MUSIC Inventory measures five primary components of the MUSIC Model of Motivation: empowerment, usefulness, success, interest, and caring (Jones & Skaggs, 2016). The components of the MUSIC model are not directly related to any one specific construct because they are names of categories of teaching strategies that can be used to motivate students. eMpowerment shows the degree to which a student perceives that he or she has the control of his or her learning environment in the course. Usefulness illustrates the degree to which a student perceives that the coursework is useful to his or her future. Success demonstrates the degree to which the student perceives that he or she can succeed at the coursework. Interest exhibits the degree to which the student perceives that the instructional methods and coursework are interesting. Caring reveals the degree to which the student perceives that the instructor cares about whether the student succeeds in the coursework and cares about the student's well-being.

3. SURVEY AND ITS RESULTS

Surveys based on the MUSIC® Model of Academic Motivation Inventory took place at the end of January 2018. Questionnaire consisted of two parts – first with 26 questions where answers were based on six-point Likert (Likert, 1932) scale and second with open-ended questions. The first one was filled by 166 students out of 196 participating in the course (85%), the second by 112 out of 196 (57%). Difference in numbers of answers is perhaps caused by the fact that the second questionnaire was more time consuming and required not only clicking but also typing. In both surveys Google Forms were used for both parts of the questionnaire (see Figure 1).

3.1 Results of the MUSIC Inventory

Students completed a questionnaire that contained items from previously validated instruments presented in (Jones, 2010). The questionnaire was titled generically as an "Applied Computer Science Questionnaire" and was part of a larger study that examined students' motivation-related perceptions about their current computer science classes. The items were scaled using a 6-point Likert-type format with the following descriptors: 1 strongly disagree, 2 disagree, 3 mostly disagree, 4 mostly agree, 5 agree, and 6 strongly agree.


Oceń poszczególne stwierdzenia używając poniższej skali
[Please rate the items in this section using the following scale:]

1 Absolutnie nie zgadzam się [Strongly disagree]
2 Nie zgadzam się [Disagree]
3 Trochę nie zgadzam się [Somewhat disagree]
4 Trochę zgadzam się [Somewhat agree]
5 Zgadzam się [Agree]
6 W pełni się zgadzam [Strongly agree]

Termin coursework czyli aktywności kursu (czyli zajęcia ale rozumiane szerzej niż tylko wykłady i ćwiczenia!) odnosi się do wszystkiego co robisz w ramach kursu włączając w to zadania, aktywności, lektury.
[Note that the word "coursework" refers to anything that you did in the course, including assignments, activities, readings.]

*Required

1 Aktywności w kursie przykuły moją uwagę *
The coursework held my attention

	1	2	3	4	5	6	
Absolutnie nie zgadzam się	○	○	○	○	○	○	W pełni się zgadzam

Figure 1. First page of the MUSIC® questionnaire
Source: Own work

The instruments measured five constructs:

– Five items measured empowerment (I had the opportunity to decide for myself how to meet the course goals; I had the freedom to complete the coursework my own way; I had options in how to achieve the goals of the course; I had control over how I learned the course content; I had flexibility in what I was allowed to do in this course.)

– Five items measured usefulness (In general, the coursework was useful to me; The coursework was beneficial to me; I found the coursework to be relevant to my future; I will be able to use the knowledge I gained in this course; The knowledge I gained in this course is important for my future.)

- Four items measured success (I was confident that I could succeed in the coursework; I felt that I could be successful in meeting the academic challenges in this course; I was capable of getting a high grade in this course; Throughout the course, I felt that I could be successful on the coursework)
- Six items measured interest (The coursework held my attention; The instructional methods used in this course held my attention; I enjoyed the instructional methods used in this course; The instructional methods engaged me in the course; I enjoyed completing the coursework; The coursework was interesting to me.)
- Six items measured caring (The instructor was available to answer my questions about the coursework; The instructor was willing to assist me if I needed help in the course; The instructor cared about how well I did in this course; The instructor was respectful of me. The instructor was friendly; I believe that the instructor cared about my feelings.).

The reliability estimates for the scales summarized in Table 1 were acceptable (Guttman, 1945) and (Guilford, 1965), especially Cronbach coefficients (Cronbach, 1951) which are good and one even excellent.

Table 1.

Means, standard deviations and Cronbach coefficients

Component	Mean	Std.Dev.	Cronbach
Empowerment	3.598	1.249	0.879
Usefulness	4.163	1.214	0.908
Success	3.526	1.272	0.897
Interest	3.667	1.194	0.869
Caring	4.167	1.268	0.821

Source: Own work

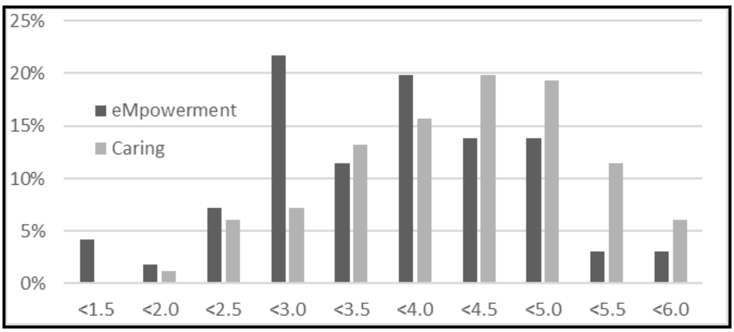


Figure 2. Comparison of the results obtained for eMpowerment and Caring
Source: Own work

The greatest differences in results are observed for empowerment and caring (see Figure 2). Perhaps it is due to the fact that the course is too much constrained and there is too little control given to students.

Generally, the results show central tendency bias (Douven, 2017), (Olkkonen, McCarthy & Allred, 2014), typical of Polish students. Figure 3 presents an average of all results for all constructs.

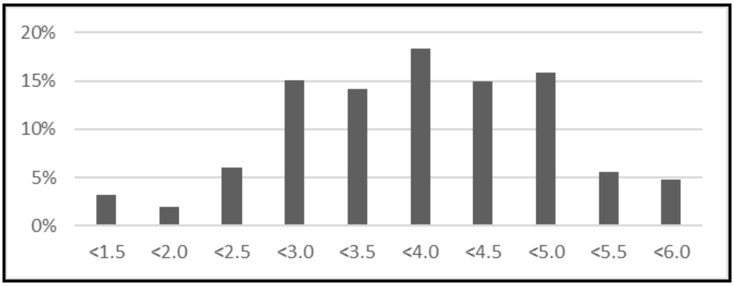


Figure 3. Central tendency bias.
Source: Own work

3.2 Open-ended questions

In addition to the inventory five open-ended questions based on (Jones, Watson, Rakes & Akalin, 2012) were asked (see Table 2). These questions were used to gain further insight into those aspects of the course that contributed to or detracted from the MUSIC component. From the list of sixteen questions prepared and used by Jones five were chosen.

Table 2.

Open-ended questions for students

Component	Question
Empowerment	What could be changed in this course to make you feel you had more choices in the course?
Empowerment	Which aspects of this course give you control over this course?
Usefulness	What could be changed in this course to make it more useful to you?
Success	What could be changed in this course to help you feel you could be more successful in it?
Interest	What could be changed in this course to make it more interesting and enjoyable?

Source: Own work based on (Jones et al., 2012)

For analysis of the open-ended items a thematic whole text analysis was used (Jones et al., 2012). An initial coding scheme for the item responses was developed after reading all of the responses. Results of this procedure for the last question - What could be changed in this course to make it more interesting and enjoyable is presented in Table 3.

Table 3.
Answers on the last question – what could be changed...

Response	% Overall Responses
Lack of answer	29%
Nothing	18%
I do not know	14%
Assessment methods	6%
Lectures and test	5%
More practice	5%
Other responses	23%

Source: Own work

3.3 Preliminary Cluster Analysis

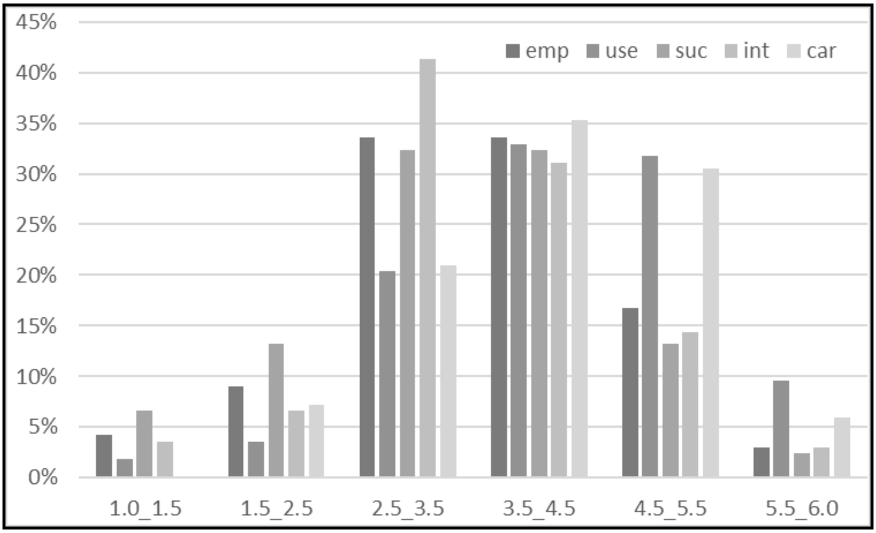


Figure 4. Clusters for separate components.
Source: Own work

The purpose of cluster analysis is to maximize within-cluster homogeneity and between-cluster heterogeneity (Chittum & Jones, 2017). In order to define the cluster profiles, the cluster centres were first organized into six categories that described the students' reported perceptions, per the 6-point scale: very low

(1.0 to 1.499), low (1.5 to 2.499), somewhat low (2.5 to 3.499), somewhat high (3.5 to 4.499), high (4.5 to 5.499), and very high (5.5 to 6.0). Results are presented in Figure 4. The biggest differences are observed for usefulness and caring.

Using the very low to very high categories to explain each variable's cluster centre within the overall cluster membership, initial characterization of the five clusters was as follows (Chittum & Jones, 2017): Cluster 1 - low motivation; Cluster 2 - low usefulness and interest, moderate empowerment, and high success and caring; Cluster 3 - somewhat high motivation; Cluster 4 - somewhat high empowerment, usefulness, and interest, and high success and caring; Cluster 5 - high motivation. Such simplified analysis can also be performed by using of k-means (Macqueen, 1967) (Figure 5) and online k-means clustering calculator.

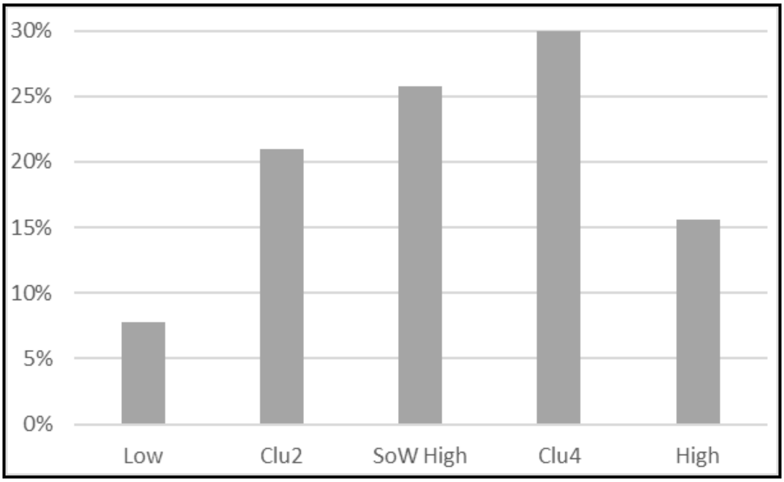


Figure 5. Clusters – simplified analysis.
Source: Own work

CONCLUSION

Outcomes of the first pilot MUSIC Inventory survey show a big difference in the results for empowerment and caring. Answers to the open-ended questions were the most valuable part of the survey. Knowledge about students' motivation will help to design courses that engage students in learning. It also leads to the next question. Is it possible to increase students' motivation and, if it is, how to do that?

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SUPPORTING MATHEMATICAL AND DIGITAL COMPETENCES USEFUL FOR STEM EDUCATION

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Abstract: *Acronym STEM (Science, Technology, Engineering, and Mathematics) has become very frequently word among many stakeholders in the school policy. Mathematical and computational thinking are important for STEM Education. There are common thinking skills, but computational thinking focuses more on automation. Mathematical thinking focuses more on proofing. We present n our contribution the theoretical requirements that are needed for students in mathematical and digital competences. Practical examples represent, how it is possible to develop mentioned competences in educational practice.*

Keywords: STEM Education, mathematical and informatical thinking, mathematical and digital competencies, competitions Bebras and Mathematical Olympiad, language and technology.

INTRODUCTION

The acronym STEM (Science, Technology, Engineering, and Mathematics) is the term, which is very frequently used among many stakeholders in the school policy. According El Nagdi et al. (2018) many real-world problems are complex and need multidisciplinary approach. Tackling such problems requires not just the ability to use design thinking or inquiry, but also the ability to choose the best approach or combination of approaches that capitalizes on the strengths of each way of thinking. From this perspective, STEM encompasses the content, skills, and ways of thinking of each of the disciplines, but it also includes an understanding of the interactions between the disciplines and the ways they support and complement each other. It is important for each STEM discipline in education to build notions with better understanding by each learner.

Every STEM subject uses mathematical knowledge and thinking. For this reason, it is important to support development of mathematical competences. Recommendation (2006) defines mathematical competence as the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations. Building on a sound mastery of numeracy, the emphasis is on process and activity, as well as knowledge. Mathematical competence involves, to different degrees, the ability and willingness to use mathematical modes of thought (logical and spatial thinking) and presentation (formulas, models, constructs, graphs, charts). For this goal it is important to use real-world problems with practical applications.

It is important for necessary knowledge in mathematics includes a sound knowledge of numbers, measures and structures, basic operations and basic mathematical presentations, an understanding of mathematical terms and concepts, and an awareness of the questions to which mathematics can offer answers. An individual should have the skills to apply basic mathematical principles and processes in everyday contexts at home and work, and to follow and assess chains of arguments. An individual should be able to reason mathematically, understand mathematical proof and communicate in mathematical language, and to use appropriate aids. A positive attitude in mathematics is based on the respect of truth and willingness to look for reasons and to assess their validity.

Digital competence involves and obtains the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in Information and Communication Technologies (ICT): the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet.

Digital competence needs a sound understanding and knowledge of the nature, role and opportunities of IST in everyday contexts: in personal and social life as well as at work. This includes main computer applications such as word processing, spreadsheets, databases, information storage and management, and an understanding of the opportunities and potential risks of the Internet and communication via electronic media (e-mail, network tools) for work, leisure, information sharing and collaborative networking, learning and research.

The main goal of the article is to present the theoretical requirements that are required of students in mathematical and digital competences. The second goal is to present practical solutions that will allow the education of these requirements set out in the theoretical part. The examples are selected so that they build competences and skills commonly referred to as computational thinking. To this end, the authors presented specific exercises that can be used in school practice to achieve the theoretical assumptions made by the requirements.

Skills needed for digital competence include the ability to search, collect and process information and use it in a critical and systematic way, assessing relevance and distinguishing the real from the virtual while recognising the links. Individuals should have skills to use tools to produce, present and understand complex information and the ability to access, search and use internet-based services. Individuals should also be able use IST to support critical thinking, creativity, and innovation.

Use of IST requires a critical and reflective attitude towards available information and a responsible use of the interactive media. An interest in engaging in communities and networks for cultural, social and/or professional purposes also supports this competence.

1. MATHEMATICAL COMPETENCES

The State Educational Curriculum in mathematics for lower secondary level (see SEC (2014)) expects that pupils:

- obtain the ability to use mathematics in their future life,
- develop their logical and critical thinking,
- learn to argue, communicate, and collaborate in a group by problem solving,
- can recognize mathematics as part of human culture and an important tool for social progress,
- can read with understanding compact texts containing numbers, dependencies and relationships and discontinuous texts containing tables, graphs, and diagrams,
- use understandable and mastered procedures and algorithms to solve problems, they can also to mathematize the real situation and interpret the obtained results,
- search, retrieve and process obtained information from adequately processed resources, including work with textbooks and another texts,
- develop skills that are related to the learning process, to teaching activities and to rational and independent learning.

Mathematics education in lower secondary level participates in developing pupils' ability to use ICT resources to search, process, store and present information. The use of appropriate software should facilitate some difficult calculations or procedures and also should focus on the base of the solved problem.

Computer aided mathematics education should lead to building a relationship between mathematics and reality, gaining experience in mathematical real-world situations and creating mathematical models. Open source software such GeoGebra helps to create many suitable models during the teaching hour.

2. INFORMATICAL COMPETENCES

The concept of IT (Information Technology) competence is based on two perspectives, which are particularly important in the context of considerations regarding new technologies: Jan van Dijk's model (Van Dijk, 2012) of access to new media and the information-knowledge-wisdom model of Neil Postman (Postman, 2011). The Van Dijk model includes four levels of access to new media:

- motivational access
- physical access,
- skills access,
- usage access.

The basic issue that decides about using new technologies is motivation (motivational access) - it depends on the decision to buy a computer and network connection and to acquire the skills necessary to use the appropriate applications. The next issue is physical access to computers and the Internet at home, work, school or other place (material access), and it also benefits from them, as access does not have to mean use (especially with no motivation). As a third level, van Dijk distinguishes competence access, as the use of computers and the Internet requires appropriate competence in the use of software, searching for information on the network, assessment of its credibility and suitability as well as the ability to process it and use it for its own purposes.

One of the documents that presents the scope of digital competences is the recommendation of the European Commission, which indicates in the document "European approach to media literacy in the digital environment" (Pérez-Tornero, Paredes, Baena, 2010) as the priority of the following issues of media and information education:

- ease of use of all existing media, from newspapers to virtual communities;
- active use of media through, interactive TV, using search engines or participating in virtual communities;
- critical approach to media regarding their quality and content;
- creative media use;
- understanding of the media economy and the difference between pluralism and the media market;
- awareness of issues related to copyright that are necessary for the "culture of legality".

Thus information literacy, it is defined as a set of knowledge and skills determining effective use of information resources, from the moment of recognizing the information gap, by defining information needs, selecting information sources, finding desirable information in them and critically evaluating them, to using them in his work and presenting to the recipients in the right form.

The importance of information competences is unquestionable, as they are - apart from preparing for the process of lifelong learning - one of the key conditions for the citizen's participation in the information society and decide on its development. These competences acquire particular importance especially in the perspective of the development of new information and communication technologies and the avalanche development of electronic information sources (Savolainen 2002).

The widespread use of such concepts as information noise, disinformation or information overload, indicates that information not only surrounds every human being, but can also be hemmed in. And this in turn means that every person should have a team of knowledge skills, allowing for efficient use of information resources. These skills can be grouped in several areas (Dąbrowska, Drzewiecki, Górecka 2012).

The first of the highlighted areas is in its essence most closely related to the problems of information sources and concerns such issues as knowledge of these sources and the ability to choose the ones that will be most suitable for the implementation of a given task. This is, therefore, a general "orientation" in the available sources of information and the ability to choose those that, in terms of credibility, ease of access, and adjustment to the age of users will be the most appropriate for the implementation of a given task.

The second area concerns the process of using selected sources, and thus direct search of information. This area includes issues related to the ability to build appropriate strategies and the selection of appropriate information retrieval techniques, and therefore such skills as, for example, narrowing down search results, using logical operators, etc.

The third area concerns the critical approach. This set of issues includes both critical assessment of sources and the information itself as well as information verification and evaluation processes.

The fourth area contains elements of work using information and information management. This area includes issues such as organizing and classifying information for personal use, recording and improving the results of work, as well as presenting it in a form that best suits the needs of recipients.

3. PYTHON AS A TOOL FOR EDUCATION OF PROGRAMMING

According to the Computing Our Future report (Computing Our Future, 2015), programming has already been introduced into education programmes in most European Union countries. The leading countries in this area include Great Britain and Denmark. The teaching of programming in schools is supported by educational programs run by non-governmental organizations and commercial entities. It looks a bit different in the United States, where the most programs devoted to learning programming work. There, it is primarily a domain of informal, or commercial, education (in the form of paid courses) and charity (educational programs of non-governmental organizations).

Also, in Poland, the emphasis on programming from an early age has increased. From the 2017 school year, a new core curriculum was introduced, thanks to which: the school will create conditions for students to acquire knowledge and skills needed to solve problems using methods and techniques derived from computer science. In Polish schools the number of IT hours increased from 210 to 280 hours, because - as the head of the Ministry explains - we want the Polish school to respond to the needs of the 21st century. The change applies from the 4th grade to the completion of secondary school. The new core curriculum also includes classes I-III, where the emphasis has also been on IT education.

Python is an interpreted, high-level, general-purpose programming language. Created by Guido van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. (Kuhlman 2009).

Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library (Kuhlman, 2009).

Python, like other high-level languages, has many typical programming constructs, such as conditional statements, loops, variables and specific syntax characteristic of this language. For example, a parallel assignment (a, b = B% a, a), generators (yield), or written lists ([len (word) for woord in words]). In general, we deal with difficult problems in programming, which require a lot of mathematical knowledge. However, there are a few tasks, we will present one of them, which can be presented in an accessible form for the recipient with the benefit of his development of thinking, not just rewriting the code.

4. MATHEMATICAL AND INFORMATICAL THINKING IN EXAMPLES

Mathematical and digital competences need support during the educational process with suitable activities. One of them are competitions Mathematical Olympiad (2006) and Bebras (2019). They develop mathematical and informatical thinking. It is important in school education to develop thinking ability, not only knowledge of facts. Problem solving strategy is also important for these competitions.

To illustrate, in Bebras competition there was the following example:

Example 1. To arrange a dinner party Sara needs to talk to five friends: Alicia, Beat, Caroline, David and Emil. Sara can talk to Emil right away. However, to talk to her other friends, there are a few points to consider:

- Before she talks to David, she must first talk to Alicia.
- Before she talks to Beat, she must first talk to Emil.
- Before she talks to Caroline, she must first talk to Beat and David.
- Before she talks to Alicia, she must first talk to Beat and Emil.

In what order should Sara talk to all of her friends if she wants to talk to all of them?

Solution:

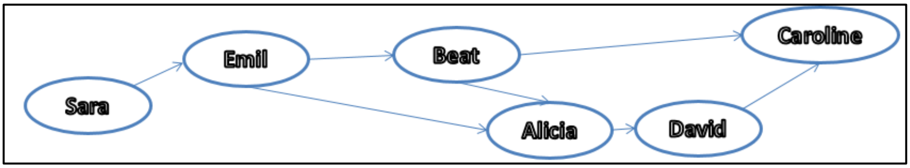

Figure 1. Solution of the Example 1

Source: Own work

The previous example used logical and combinatorial thinking. These kinds of thinking are possible to use in the following example from Mathematical Olympiad for 15 year old pupils in Slovakia:

Example 2. How many six-digits numbers exist, which have the product of digits the number 750?

Solution: The base for the solution is decomposition of the number 750 to prime numbers. It is 750 = 2. 3. 5. 5. 5.

It is possible from this decomposition to create six-digits numbers only in the case, that we use digits from this decomposition and the digit 1 at least once. It brings two possibilities:

- We have digits 1, 2, 3, 5, 5, 5. We obtain in this case (6!):(3!) = 6. 4. 5 = 120
  - possibilities.
- We can make from the digits 2 and 3 the digit 2.3 = 6. We use in this case
  - the digits 1, 1, 6, 5, 5, 5. We obtain (6!):(3! . 2!) = 6. 2. 5 = 60 possibilities.

Altogether we have 120 + 60 = 180 possibilities.

The purpose of the following exercise prepared in Python is to show that each logical problem can be solved by means of stages and its simplification in the form of a sequence of code lines, which constitute an algorithmic part of the task. At each stage, the student may interrupt the work and ask additional questions. The greater the student's level of competence, the more stages he will solve himself.

In Polish education there is no recommendation as to which programming language to choose - a particular language is free in its choice, so the teacher can choose the programming language that best suits the requirements for hardware and software in its class.

Example 3: Write a function for (x, y), which will result in a number specifying the day, when a small beetle is at the top of a 10-meter pole. Assumptions for the task: beetle climbs by (x) centimetres in the day and falls by (y) centimetres at night. We assume that (x> y).

Example: The result for (300,100) is 5. The result for (4,2) is 499. The task comes from the LOGIA 13 competition, the first stage.

Necessary knowledge to solve: the student should know the basic mathematical operations (+, -, /, *), and complete division and sharing with the rest. The student should also know how to define a function in programming.

Solution: We will solve the task in stages with further difficulties. At the beginning, let's assume that the beetle climbs only and does not fall at night. It is for the value (y) that we must assume that: (y = 0). Then you have to assume that 1000 units is a multiple (x).

Then we will consider cases in which not necessarily 1000 is a multiple (x). Then we solve the problem, where (y) can take any value, that is, we have to subtract (x) from (y).

Consider the question when the beetle is at the top of a ten-centimetre pole if it climbs by (x) centimeters every day without falling off at night.

Assuming that 1000 is a multiple (x), it will be:

Def when (x):

Return 1000 // x

If we do not know if 1000 is a multiple (x), then the problem is a bit more difficult. We assume that we do not use other mathematical functions, e.g. rounding up. Auxiliary question, which we can present, when it will be at a height that allows one day to climb to the top. Then you have to add one day for the beetle to enter the pole.

Def when (x):

Return (1000-1) // x + 1

It is not difficult to notice that if the day falls by (x) and falls by (y) at night, he overcomes (x-y) daily. As in the first example, we assume that 1000 is a multiple (x-y).

Def when (x, y):

Return (1000 // x-y

Finally, we go to solving the right task: beetle in the day enters by (x), and at night it decreases by (y), and 1000 does not have to be a multiple (x-y).

Def when (x, y):

Return (1000-y-1) // (x-y) +1

We can find these materials in Python (2019). The above code can be tested on several examples. The task does not require advanced programming and mathematical skills. The task, however, is not easy. A standalone solution, however, is perfect for a novice programmer.

5. CONCLUSIONS

Mathematical and computational thinking are both essential in problem solving. There are common thinking skills, but informatical thinking focuses more on automation. Mathematical thinking focuses more on proofing. Pupils develop also their cognitive abilities and correctness to formulate properties of mathematic objects (see Kopáčová, Žilková, 2017). Using ICT with cognitive abilities of pupils obtained during the mathematics lessons is important in STEM Education. Interesting examples can be found in Koreňová, Fuchsová (2019). The greatest advantage of programming in Python is its simplicity based on the use of commands in it, which are literal meanings, e.g.: def, return (a + b), which in turn allow to: define, return values from adding. Another advantage is expressivity, which is ‘expressed’, it means the use of a small amount of code as opposed to other languages like java, JavaScript, C ++. The last significant advantage of the didactic point is the fact that in Python do not need to define minors as guilty languages. In Python, just a number or word is given. In other languages, you must assign this data to specific types, for example: "int", "string", "boolean".

These three advantages make solving logical, mathematical and algorithmic problems very intuitive, simple and short, which allows the student to focus on the problem, not to learn the details of a given programming language. It should be remembered that computational thinking has many features of any programming language, i.e. it can be in today's world of communication medium of the real and virtual world, and it can be a medium of cognition in general. Ludwig Wittgenstein truly gives this essence: "The limits of my language mean the limits of my world." (Martland, 1975). Today, this quote in the context of technology can be paraphrased: "The borders of our programming language of technology are the limits of our knowledge of the world through technology." Therefore, the development of competence in the field of computational thinking contributes to development: logical thinking, creativity in the search for solutions, heuristic thinking, algorithmic thinking, and innovation (see Papert, 1980).

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DIGITAL COMPETENCE: ABILITIES OF A LECTURER AND EXPECTATIONS OF STUDENTS (UKRAINIAN-POLISH CONTEXT)

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Abstract: *The task of shaping the IT competence of a modern teacher, in particular academic teacher, is quite current and important. It is associated with the turbulent development of information and communication technologies, with the formation of an information society. The purpose of the article is to analyze the features and dynamics of the formation of digital competence of university lecturers in Ukraine and Poland, to identify and justify the direction of increasing the digital competence of lecturers of higher education. Has presented the positive experience of universities of Ukraine and the Republic of Poland in improving the level of digital competence of teachers, recommendations of research teams on improving the digital competence of lecturers and conclusions and prospects for further research*

Keywords: digital competence; competence development; teacher of higher school; advanced training; digital technologies.

INTRODUCTION

Modern strategies of developing higher school and improving its quality largely depend on the human resources of higher education institutions as well as the readiness of lecturers to change and introducing new educational trends into practice. Among these trends, the leading place is occupied by digital technologies.

Today their use in the educational process is not only a requirement but also the norm. In this context, the requirements to the activities of higher school lecturers are changing; irreversible are the transformations in the sphere of their professional competence, in particular the digital one. In 2018, it was the digital competence, comprising confident, critical and responsible use and interaction with digital technologies for education, work and life in society, which was defined as one of the key lifelong learning skills (according to the updated recommendations of the European Parliament and the Council of the EU (Council Recommendation, 2018).

At the same time, the analysis of experimental data on the development of competencies of lecturers of higher education shows the lack of formation of such a system-forming competence as the digital one (Khoruzhaya, Bratko, Kotenko, Melnychenko, Proshkin 2018). In modern social and cultural conditions, when the growth of a new generation takes place in a rich and dynamic information environment, lecturers in the information age need to achieve a new level of professional activities. As T. Noskova mentions, it is necessary to teach, develop, and educate young people not only by means of pedagogical communication but also by instrumental means of the electronic environment (Noskova, 2016).

Consequently, there is a need to study the real state of lecturer`s digital competence development, as well as the development of ways to improve their information literacy, showing opportunities for effective communication and cooperation, the creation of digital content, etc.

I. BACKGROUND RESEARCH

Activities of modern higher school lecturers take place in both global and local contexts. The world has become mobile, dynamic development, digital. Therefore, the methodology of the study was based on the analysis of the real state of digital competence development of lecturers as performers of an important social mission.

For the study, higher school lecturers from two countries – Ukraine and the Republic of Poland – were selected. These countries have shifted from post-socialist countries to the universally recognized European values, close to each other in their history and culture.

In Ukraine, the development of informatization of education takes place in accordance with national and European programs ("Digital agenda of Ukraine – 2020" (Digital agenda, 2016), containing priority areas, initiatives, projects of digitalization of Ukraine until 2020, the program "UNESCO ICT competency framework for teachers" (UNESCO ICT competency, 2011), "European Framework for the Digital Competence of Educators" (DigCompEdu 2017) etc.

Moreover, various aspects of informatization of higher education have been the subject of research of a number of scientists in Ukraine. For example, V. Bykov and M. Shyshkina found out, that the formation of the educational and scientific environment of higher education institutions using digital technologies gives the possibility to combine science and practice, integrate the process of training and carrying out scientific research, improve results and level of organization of academic teaching activities. It is the defining trend in the development of scientific and educational information networks and systems of open education and science (Bykov, Shyshkina 2016). O. Spivakovskyi analyzed the main ways of building ICT infrastructure of the University. He studied the impact of IT development of the University on its rating indicators, identified the main components of information and communication pedagogical environment of higher education institutions (Spivakovsky, Vinnyk, Tarasich 2014). N. Morze presented a model of the standard of ICT competence of teachers in the context of European quality standards in the University educational environment (Morze, Kocharyan 2014). L. Panchenko developed a theoretical and methodological basis for the development of information and educational environment of the University (Panchenko 2010). Y. Modlo, A. Striuk, S. Semerikov, outlined the features of using augmented reality technology in a mobile-oriented learning environment of higher educational institution (Modlo, Striuk, Semerikov 2017). O. Glazunova, O. Kuzminska and others carried out a comparative analysis of using Microsoft and Google cloud services in the organization of group project work of University students (Glazunova, Kuzminska, Voloshyna, Saiapina, Korolchuk 2017).

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As has been emphasized earlier, the task of shaping the IT competence of a modern teacher, in particular academic teacher, is quite current and important. It is associated with the turbulent development of information and communication technologies, with the formation of an information society, that is, a society in which most professions are related to the search, storage, processing, presentation, transmission of various data.

In English-language literature, the term information literacy (IL) is used to describe the ability to effectively use information in the implementation of accepted tasks and goals. According to Christine Bruce, although the information literacy idea dates back to the seventies of the last century, it was only in the 21st century that it became a key competence. Although many organizations, researchers and scientists have attempted to describe information literacy, there is currently no universally agreed one common definition of the term. The definitions known from the literature most often define this concept as a set of skills related to acquiring information, ranging from the identification of information needs, to the effective use of information (Borawska-Kalbarczyk 2015: 131). The term was first used by the American educator Paul Zurkowski, the then president of the US Information Industry Association, in 1974 in the report The Information Service Emironment, Relationships and Priorities. This concept became widespread in education in the eighties of the last century, when educational programs in this field began to be developed. Their results were models and standards of information competences disseminated by such organizations as: American Library Association, Association of College and Research Libraries, American Association of School Librarians, Chartered Institute of Library and Information Professionals, Society of College, National and University Libraries. (Smyrnova-Trybulska 2018: 148).

In her research, Torlińska analyzes and states examples of the definition of the term literacy (Torlińska, 2005: 369). Currently, one of the more frequently cited is the definition proposed by the American Library Association (ALA) in 1989: information literacy is a set of skills enabling the identification of information demand and its localization, evaluation and effective use. Efficiently using information is for those who have learned how to learn. They know how to learn because they know the organization of knowledge, they can find and use information so that others can use it. They are prepared for continuous self-education because they know how to find the information needed to solve a problem or make a decision (American Library Association, 1989). (Smyrnova-Trybulska, 2018: 148).

Despite the diverse research, the issues of increasing the level of Ukrainian and Polish lecturers' digital competence, as well as the use of digital technologies for their competence development require further solutions. The purpose of the article is to analyze the features and dynamics of the formation of digital competence of University lecturers in Ukraine and Poland, to identify and justify the direction of increasing the digital competence of lecturers of higher education.

2. RESEARCH METHODOLOGY

To achieve the goal of the study we used a set of appropriate methods: analysis of scientific literature to find out the state of development of the studied problem, the definition of categorical and conceptual apparatus of the study; synthesis, generalization, systematization for the theoretical justification of the use of digital technologies for the competence development of lecturers of higher education; empirical: diagnostic (conversation, content analysis, testing), statistical (Pearson's criterion) to track the dynamics of the level of formation of digital competence of lecturers of higher education.

The article presents some results of the study obtained in the framework of the international project #21720008 "Competencies of higher school lecturers in the epoch of changes", which was implemented during January – December 2018 with the assistance of the Visegrad Fund and the Ministry of Foreign Affairs of the Netherlands. Among the performers of the project were scientists of Borys Grinchenko Kyiv University (Ukraine) and the University of Silesia in Katowice (Poland).

3. RESEARCH RESULT

3.1. Some results of the international project "Competences of lecturers of higher school in the epoch of changes"

Today, the digital world has an autonomous life and its development cannot be stopped: the Internet of things, self-organization of the network, a variety of information resources and so on. Digital reality is already a sign of selection in society. All these challenges of the digital age affect the essence of the key competences of the teacher, in particular, the digital one, as well as his willingness to change and improve in these conditions. The international project "Competences of lecturers of higher school in the epoch of changes" aimed at diagnosing the competences of higher school teachers.

In total, 621 respondents from Ukraine and the Republic of Poland as the participating countries of the project took part in the study "Competences of lecturers of higher school in the epoch of changes": 188 teachers and 433 students (see table 1).

So we had the opportunity to carry out a comparative analysis of the development of key competences of higher school lecturers, as well as determine the prospects for their improvement. Among the various competences, a modern teacher should have, the digital one requires special attention. It works as a catalyst in the activities of the lecturer, developing other key and professional competences, as they enable setting and solving professional tasks, using the possibilities of the electronic environment.

Table 1.

Summary statistics by respondents

Country	Lecturers	Students
Ukraine	125	269
Poland	63	164
Total	188	433

Source: Own work

In the proposed study digital competence includes the following structure: confident, critical and responsible use and interaction with digital technologies, work with information and use of ICT, which echoes the main provisions of the updated recommendations of the European Parliament and the EU Council for lifelong learning (Council Recommendation, 2018). Indeed, people need to understand how digital technologies can support communication, creativity, and innovation, and be aware of their capabilities, limitations, effects, and risks. It is also important to be able to use digital technologies for active citizenship, social integration, and cooperation, creativity according to personal, social or commercial goals. Digital skills also include the ability to use, access, filter, evaluate, create, program, and share digital content. Based on this, we present the criteria for the formation of digital competence of teachers: information and data literacy, digital communication and cooperation, the creation of digital content, responsible use of ICT, digital problem-solving.

Let us consider in detail how the participants of the study assessed the importance of digital competence in the professional activity of a higher school lecturer (see Table 2).

For the assessment of digital competence the respondents were expressing opinion on following issues:

- introduction of innovative learning technologies in education, in particular, ICT;
- work with information in global computer networks on the basis of its critical analysis;
- use of various means of communication with students and colleagues, including ICT;
- design of e-learning resources;
- popularization of the results of own research with the help of electronic portfolio.

Table 2

Evaluation of digital competence of lecturers according to the statements "Yes" and "Rather yes than no"

No	Competences	Ukraine (lecturers), %	Ukraine (students), %	Poland (lecturers), %	Poland (students), %
1	introduction of innovative learning technologies, in particular ICT	96.8	94.0	53.4	82.9
2	work with information in global computer networks on the basis of its critical analysis	92.0	91.8	60.0	80.5
3	use of various means of communication with students and colleagues, including ICT	96.0	94.8	73.3	90.2
4	design of e-learning resources	84.8	88.9	20.0	69.5
5	popularization of the results of own research with the help of electronic portfolio	80.0	90.7	66.7	78.6
	Average	89.9	92.1	54.7	80.3

Source: Own work

We would also mention that lecturers, involved in the experiment, carried out a self-assessment of their professional activities. At the same time, students determined their own expectations regarding activities of lecturers by giving the answer. They actually were developing a "perfect model" of a modern higher school teacher.

As Table 2 shows, the level of actual lecturer`s readiness to confident, critical and responsible use and interaction with digital educational technologies is lower than students have. Perhaps, the higher rates in the Ukrainian sample are due to the fact that the study was conducted on the basis of the University, based in the capital, which has modern material and technical equipment and an existing program to improve the digital competence of lecturers, which is not a rule for most regional universities in Ukraine.

Interestingly, both Polish and Ukrainian students, modelling the teacher's activity, evaluate digital competence higher than teachers (Ukrainian sample: 92.1% and 89.9%, respectively, Polish sample: 80.3% and 54.7%, respectively).

It should also be noted that in the Polish sample there is a statistically significant difference between the views of students and teachers. It is established that $\chi^2_{1=15,667}$, $\chi^2_{2=13,277}$, $\chi^2_2 > \chi^2_1$ for the level of significance, $p \leq 0{,}01$, where χ^2_1, χ^2_2 is the empirical and critical value of the Pearson criterion.

In the Ukrainian sample, the difference between the views of students and teachers is not statistically significant. It is established that $\chi^2_{\text{емп}=2,548}$, $\chi^2_{\text{кр}=13,277}$, $\chi^2_{\text{емп}} < \chi^2_{\text{кр}}$.

Let us consider the results of the experiment in the context of national samples.

It should be noted that clarification of the general attitude of groups of respondents to the definition of digital competence of higher school lecturers was not fundamental. According to the research which took place at progressive capital university, the most important thing was to find out how the groups differ by the established statement "Yes", which is considered as an indicator of the real readiness of lecturers to changes, the definition of their own decisive position.

Thus, 60% of Ukrainian lecturers note that they are constantly introducing new innovative technologies in education, including ICT, and 36.8% are in the zone of instability and partially use these technologies. Students' responses almost coincide with teachers' assessments, which indicates the real state of the use of ICT in education.

Statistical analysis showed that teachers aged 41 to 55 (62.2%) and those aged 56 to 70 (66.7%) were more active in using ICT. Candidates of Science are more active in using ICT (66.1 %) compared to Doctors of Science (46.2 %).

Continuing the analysis, in our opinion, quite controversial is the fact that teachers’ determination to ensure professional self-improvement, the use of ICT in the educational process is not correlated with their willingness to work with information in global computer networks based on critical analysis – 48.8 %. In our opinion, this fact is evidence, on the one hand, of the lack of necessary knowledge and skills to deal with information, to select necessary information and apply in the educational process, and, on the other hand, of low motivation to work with it. At the same time, the teachers’ ability to work with information in global networks significantly expands their professional capabilities, increases the technological effectiveness and quality of the educational process.

The greatest willingness to work in global networks was shown by young lecturers aged 25 to 40 years (50 %), although other age groups (about 48 %) confidently answered this question; 48.8 % aged 41 to 55 years and 42.9 % of respondents from 56 to 70 years have a somewhat unsteady position in this question.

Most Doctors of Science (69.2%) actively work with information in global information sources and critically interpret it. Among lecturers without a degree, the amount is less, only 44.6 %. One of the reasons for this is the insufficient level of scientific critical thinking and development of respondents' thinking operations.

The ability to work with information and use various IT in the educational process (video presentations, distance learning, online courses, etc.) provides the direct designing of electronic learning resources by the lecturer. Only 40 % of teachers confidently replied that they design such resources, 44.0 % are not always ready for such work, and more than 15% do not know how to do it, so categorically replied "no". Students were more demanding to teachers and 56.5% of them consider it an obligatory component of the lecturer's activity.

According to statistics, young lecturers aged 25 to 40 years (43.1%) and teachers aged 56 to 70 years (47.6%) actively create e-learning courses and, respectively, 39.6 % and 42.8 % noted that "Yes, rather than no". Statistics also showed that only 33.3% of teachers aged 41 to 55 years create such courses, and 51.1% are in the zone of unstable choice and answered "Rather yes, than no". The high level of creation of e-learning courses was demonstrated by Doctors of Sciences (61.5%). The indicator for Candidates of Sciences (37.7 %) and teachers who do not have an academic degree (37.5%) was significantly lower. The last category of lecturers (more than 25%) has chosen "Rather no, than yes" and "No".

It should be mentioned, that the quality of the implementation of digital technologies into the practice of University education largely depends on the ability of teachers to build interaction with students on the competence basis using a variety of interactive methods. The advantage of self-study work in the structure of students' cognitive activity, interactive methods of working with them, moving from the traditional forms of organization of the educational process makes the interaction of the lecturer with students the dominant of his professional and pedagogical activity. 74.4 % of lecturers claim that they actively use various means of communication with students and colleagues, including ICT. This figure correlates with the one, shown by students, - 70.6 %. All age groups of lecturers surveyed (the same indicators ranging from 70,0% to 75,5%) showed active communication with students and colleagues, including using ICT. According to the academic degree, the least ready for such communication were Doctors of Sciences (69.2 %), and the most active – Candidates of Sciences (77.4 %).

One of the most important components of the professional activity of lecturers of higher education is the scientific work. Every higher school teacher, carrying out scientific research, necessarily considers its presentation and the dissemination of its results. It happens through scientific publications, presentations at conferences, seminars, but does not exclude popularization through lectures, the use of their own scientific research in the process of teaching, starting their own scientific school, creating a personal scientific portfolio, in particular electronic, opened to the wider public. Thus, we are interested in finding out the opinions of lecturers on the need to dissemination their research results.

In the context of our research, 49.6% of respondents clearly approve dissemination of their scientific research through an electronic portfolio. Another 30.4% fluctuate, but are inclined to answer "Rather yes, than No". So, 79.6% of respondents show a positive attitude to the electronic portfolio as a means of popularizing their own research. The answer "No" was given by 5.6%, including 43% - Candidates of Sciences. A shaky position "Rather No, than Yes" was shown by 14.4% of respondents. Among them, 44.5% of lecturers with scientific degrees, including Doctors of Sciences aged between 41 to 55.

In the examined group of Polish academic teacher, women (76%) dominated over men (24%). The largest age group was 41-55 years (49%), the age 25-40 constituted 35% and 56-70% - 16% of the respondents. As the declared scientific degree or title is concerned, the largest group were doctors (Ph.D. holders) – 55%; there were 25% of doctors with habilitation and 20% of M.A. holders. The respondents represented similar groups as regards work seniority – 37% of people working for 11-20 years, 33% - more than 20 years and 30% - less than 10.

Most frequently, the surveyed academic teachers treated interactive collaboration with students as the most effective in the learning process. A similar number of respondents answered rather yes than no (38%) and yes (37%). In the group of teachers who are more sceptical about the interactive form of contact, 21% provided the answer “rather no than yes” and 4% - “no”.

Most frequently, the surveyed academic teachers treated interactive collaboration with students as the most effective in the learning process. A similar number of respondents answered “rather yes than no” (38%) and “yes” (37%). In the group of teachers who are more sceptical about the interactive form of contact, 21% provided the answer rather no than yes and 4% - no.

Much more negative attitudes were observed among the respondents in the case of the reforms and changes taking place in higher education – 41% answered rather no than yes, 38% - “rather yes than no”. A similar number of teachers provided extreme answers – 11% - no and 10% - yes.

The surveyed academic teachers are mostly satisfied with the effects of their professional work – positive answers prevailed here: yes – 46% and rather yes than no – 41%. Only 3% of respondents claimed they were dissatisfied and 10% declared the answer rather no than yes.

Over a half of the respondents (54%) stated that they perceive the young as a generation of particular values and needs, 35% chose the answer rather yes than no. Only 11% declared the answer rather no than yes. In the case of this and the next question, nobody declared the answer no. Almost all surveyed academic teachers consider themselves to be open to communication and aiming at understanding and solving complicated situations – 70% answered yes and 29% - “rather yes than no”. The quantitative distribution of data is similar in the next question, concerning the promotion of tolerance for differences among people in multicultural environments. The answer yes was chosen by 67%, “rather yes than no” – by 30%, the answers rather no than yes and no were declared by 2% per each.

In the case of implementing internationalization, the most frequent answer was rather yes than no – 35%, 30% declared the answer yes. A similar number of respondents answered that they do it in a rather small scale (27%), the definitely negative answer was chosen by 8% of teachers. The activities associated with publishing the research results were more favourably evaluated, which seems obvious due to the annual requirements concerning scientific achievements, imposed in Poland on academic teachers. 67% chose the answer yes, 29% - rather yes than no, and only few (2% and 2% respectively) declared their poor engagement in such activity. What might surprise in the context of these data are the answers to the question pertaining to diagnostic tools for analysing scientific data. 46% chose rather yes than no, 24% declared yes, but as many as 24% stated that they do this rarely and 6% that not at all. (Grabowska, Kwadrans, Minczanowska, Smyrnova-Trybulska, Szafrańska 2019)).

During the analysis of research results, the following was also conducted: the comparison of the ratios of academic teachers’ and students’ competences profiles according to Pearson’s X2 criteria (for each profile separately).

Vocational-pedagogical profile: Empirical significance/value - 1.196381457; Critical significance/value (a=0.05) - 7.814727903; Critical significance/value (a=0.01) - 11.34486673. Conclusion - No statistically significant differences.

Social-personal profile. Empirical significance/value - 1.765328537; Critical significance/value (a=0.05) - 7.814727903; Critical significance/value (a=0.01) - 11.34486673. Conclusion -. No statistically significant differences.

Academic profile. Empirical significance/value - 0.610498839; Critical significance/value (a=0.05) - 7.814727903; Critical significance/value (a=0.01) -. Conclusion - 11.34486673. No statistically significant differences.

Thus, digital competence of the lecturers involves using ICT technologies in the process of professional training and the creation of new information resources. Their availability is changing the traditional model of the educational process, creating conditions for the development of a multi-component educational model, interactive virtual environment, reshaping the interaction technology of its subjects. Considering the above mentioned the competence of a academic teacher in working with information on the basis of critical thinking, using ICT and creation of new information resources requires further development.

The essence of this process is to expand lecturer's understanding of the informational environment, to familiarize with new informational trends and opportunities for their use. ICT should be improved for teachers between the ages of 41 and 55, as well as for those without a degree.

The obtained research results show that the competences presented in the three discussed profiles are highly valued by both academic staff and students. However, they require constant raising in order to step further from the level of declarations or expectations (often different than the reality) to the stage of their professional applications. This has been and currently is facilitated within various projects, supported by outer resources from EU or national projects. Yet, our recommendations promote making the changes and support for the development of academic teachers' competences within all the three profiles an element of academic curricula and system organizational-institutional reforms – not only incidental implementation of projects. Without certain continuity and permanence in this scope, it will be difficult to achieve the desired change – increased competences of academic staff, and in turn better quality of educating students and conducting scientific research. (Grabowska, Kwadrans, Minczanowska, Smyrnova-Trybulska, Szafrańska 2019)).

3.2. Positive experience of universities of Ukraine and the Republic of Poland in improving the level of digital competence of teachers

The study found that the goals and values of higher education in project participating countries are more similar than different. In the competence space of lecturer's activities, we have identified common competency guidelines, which are associated with social, cultural, economic challenges, evolution of educational goals of the EU. Among the basic guidelines is digital competence, contributing to the implementation of the unification processes in the EU education and the ICT revolution, as well as the interaction of participants in the educational process, the adaptation of the individual to constant changes etc.

As practice shows, the Borys Grinchenko Kyiv University (Ukraine) and Silesian University in Katowice (Poland) have positive experience in improving the level of digital competence of lecturers. We are sure that such experience should be taken into account in the organization of activities at other universities in our countries. Here are some examples of activities aimed at improving the digital competence of lecturers.

1. Thus, the program of professional development of lecturers aiming at their competence development is implemented at Borys Grinchenko Kyiv University. Since 2015, the University has been operating a prolonged system of professional development in the context of the development of professional, didactic, research, digital and leadership competencies of lecturers. Within the framework of the professional development program, a content module "Information and communication technologies" was organized, aiming at developing lecturers' general ideas about the ways and prospects

of informatization in education; the ability and sense of the need for continuous self-education and self-improvement, the use of innovative pedagogical and digital technologies, web 2.0 services in the educational process (Educational program, 2015).

The program of the content module comprises the following topics:

– "Modern educational trends and ways to implement innovative technologies and ICT in the educational process";
– "Blended learning. E-learning technologies. Resources for creating e-content and criteria for its evaluation";
– "21 century skills. Internet services and IC technologies for effective communication";
– "Internet services and IC technologies of effective cooperation";
– "Internet services and IC technologies for formative assessment".

Lecturers use resources to create e-content, a variety of Internet services and information technologies for effective communication, cooperation and monitoring the quality of the educational process. In addition to this module, every lecturer can improve digital competence while developing and certifying an e-learning course to implement e-learning.

2. The University has developed the Corporate standard of digital competence of a lecturer, presented in the form of a model that covers various activities of lecturers (educational, scientific, professional development etc.) and tools to measure of digital competence within three components: technological literacy, knowledge deepening and knowledge creation. Technological literacy includes: familiarity with educational policies, basic ICT tools, basic knowledge (insufficient use of ICT in the educational process), basic knowledge in scientific communication, and ICT literacy (formal studying ICT). The second component – extending of knowledge includes: understanding of educational policy through ICT, complex ICT tools, the use of knowledge (systematic use of ICT in the educational process), the use of knowledge in scientific (including virtual) communication and electronic scientific cooperation, management and coordination (non-formal education in ICT). The third component (creation of knowledge) comprises the following components. These are innovations in educational policy, latest technologies, skills of the society of knowledge, skills of implementing scientific projects, and training in open access courses. We also highlight the most important tools for measuring the technological literacy of teachers of higher school:

* Survey to identify teachers' awareness of the availability of educational policy documents (at the state or University level) and their role in University activities.

– Self-checking tasks to test levels of knowledge of the basic tools.

- Survey of students on the quality of ICT usage in the educational process.
- E-testing of educational achievements of students.
- The availability of EEC on the LMS Moodle platform.

* Questioning teachers to understand the effectiveness of ICT usage in practice.

- Survey of teachers on awareness of the use of scientific communication: repositories, scientometric databases, e-libraries, e-magazines, online conferences.

Citation index in Google Academy, etc. (Corporate standard 2015).

3. In order to ensure the accumulation, systematization and storage of intellectual products of the University in electronic form, the University operates the Institutional repository of the Borys Grinchenko Kyiv University, which is designed for the accumulation, systematization and storage of intellectual products of the scientific community of the University in electronic form, providing open access to them by means of Internet technologies, distribution of scientific materials in the world scientific space (Regulations 2015). It is an open-access resource, located on the University server on the Internet and accessible from any place and at any time.

The repository allows you to view and sort information by criteria: year, subject (abstracts, dissertations, reports on scientific projects, reports of structural units, monographs, musical works, teaching materials, manuals, scientific publications, scientific conferences, scientific schools, normative documents, patents for inventions, textbooks, certificates, certificate for registration of copyright for a scientific work, dictionaries, encyclopedias, reference books, articles in journals, articles in scientometric databases), structural unit and author.

The University of Silesia e-learning platforms provide students with more than 8,000 hours of effective work (http://el.us.edu.pl), The Faculty of Ethnology and Sciences of Education has developed a distance learning platform for training and educational activities (http://el.us.edu.pl/weinoe). IRNet Project (www.irnet.us.edu.pl) e-learning course ICT-tools for e-learning (http://el.us.edu.pl/irnet) includes more than 10 topics devoted innovative ICT-tools and methods, elaborated by dozens of experts from 10 countries, aimed at academic teacher and future teachers. This core graduated above 110 learners. At the end of the year there will be prepared upgraded MOOC in Edex system.

Distance Learning Center of the University of Silesia provides technical support, course administration and training for teaching staff and students. On the platforms of the Center for Distance Education at the University of Silesia, from the beginning of the activity there were registered 133 850 users who used teaching support in the remote mode. This year, 24,800 active platform users have been registered. 1556 EL teaching support courses have been developed.

*Open Source publication (*e.g., Repository (https://rebus.us.edu.pl), digital Library (www.ciniba.us.edu.pl), includes more than 100 000 publications; Bibliography of the work of the employee of the University of Silesia. The repository of the University of Silesia RE-BUŚ was established in order to disseminate scientific achievements of employees, promote scientific research conducted at the University of Silesia, as well as to support didactic processes. RE-BUŚ contains full texts of publications of employees, associates, doctoral students and students of the University of Silesia. The creation of the University of Silesia Repository was co-financed by the Ministry of Science and Higher Education (Agreement No. 645 / P-DUN / 2017).

The Flagship Initiatives for the three aforementioned priorities are as follows:

Smart growth: Digital Agenda for Europe; Innovation Partnership; Youth on the move.

Sustainable growth: A resource-efficient Europe. Industrial Policy for a Globalised Era.

Inclusive growth: Agenda for new skills and jobs. The European Platform Against Poverty and Social Exclusion.

Poland's *National Reform Programme* is part of a broader initiative intended to develop an effective system shaping the country's policy (Strategy of University of Silesia on 2012-2020).

3.3. Recommendations of research teams on improving the digital competence of lecturers

The conclusions made by international research teams regarding the results of the diagnostics of lecturers' digital competencies and their generalization give grounds for justification of recommendations on certain changes that should be implemented at the institutional, and national levels.

1. The beginning and holding of the international (Polish-Ukrainian) summer school for the development of digital competence of higher school lecturers (rough topics: "Academic integrity as a guarantee of the formation of a modern scientist in the information space", "Ethical, legal and socio-cultural problems of the information society", "Formal and informal education in informatization environment", "Communication and information: points of contact", etc.)
2. Clarification of the structure of digital competence of higher school lecturer, monitoring of its formation in accordance with certain components.
3. Organization and holding of a series of master classes "Using software and hardware ICT in higher school."
4. Holding a scientific and methodological seminar on digital intelligence: using digital content in everyday life and in professional activities.

5. Joint scientific publications on comparison research in the *International Journal of Research in E-learning (*http://weinoe.us.edu.pl/nauka/serie-wydawnicze/international-journal-research-e-learning), which got the grant of Ministry of Science and Higher education, recommendation for publication in area Pedagogy discipline and 20 points.

CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

1. The results of the international project "Competencies of a higher school lecturer in the epoch of changes" (No 21720008) aimed at diagnosing a number of competences of higher school lecturers in Ukraine and Poland indicate a fairly low level of formation of such a system-forming competence as a digital one.
   This competence comprises the ability to new, which is realized when using ICT technologies in the process of professional training and the creation of new information resources. Their availability changes the traditional model of the educational process, creates conditions for the development of a multi-component educational model, interactive virtual environment, reshaping the technology of interaction of its subjects. Considering the above mentioned, the competence of lecturers in working with information on the basis of critical thinking, using ICT and the creation of new information resources requires further development.
2. The positive experience of Borys Grinchenko Kyiv University and the Silesian University in Katowice in improving the digital competence of lecturers includes the development of lecturers' general ideas about the ways and prospects
   of informatization in the field of education; the ability and sense of the need for continuous self-education and self-improvement, the use of innovative pedagogical and digital technologies, Web 2.0 services in the educational process.
3. The recommendations of research teams regarding the improvement of the digital competence of higher school lecturers are prepared. They cover the organization and holding of a number of activities (summer school, workshops, seminars, etc.), clarifying the structure of digital competence of teachers, etc.
4. Presentation and dissemination of research results on the International Scientific Conference *Theoretical and Practical Aspects of Distance Learning* (www.dlcc.us.edu.pl) and publications of joint articles in the scientific monograph series on E-learning (http://weinoe.us.edu.pl/nauka/serie-wydawnicze/seria-e-learning/seria-e-learning), indexed in Web of Science.

The provisions considered in the paper do not dwell on all aspects of the problem studied. The development of methods for the use of digital technologies for the implementation of the program of competence development of lecturers of higher school will be the subject of further scientific research.

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E-FORUM MODERATION AS AN ELEMENT OF BLENDED LEARNING COURSES FOR UNIVERSITY STUDENTS. A RESEARCH - BASED STUDY

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Abstract: *E-forum is widely recognized to be an effective method of students' learning. Research on processes and phenomena in synchronous (SOD) and asynchronous (AOD) discussion at e-forum date back to the first years of the new Millennium and explore both the role and tasks of the moderator as well as complex preconditions of a productive and satisfying students' participation. The present article focusses on moderation of e-forum discussion and in particular, on two crucial and challenging moments in e-forum moderation: opening and closing. The co-authors of this paper have constructed their perspective on e-forum moderation upon analysis of the role of discussion in the teaching/learning process in face to face, e-learning, and b-learning settings. The final remarks and postulates follow conclusions from the original research study.*

Keywords: e-forum moderation, online discussion forum, blended learning, e-learning, discussion, teacher role, student learning, teaching/learning process, AOD, starting a discussion forum, closing down a discussion forum

INTRODUCTION

Traditional teaching methods (like lecture and readings) are efficient enough at basic knowledge acquisition. Bloom’s cognitive taxonomy identifies six levels of cognitive taxonomy: (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, (6) evaluation (1956). At this level (the first level in Bloom’s taxonomy), there is no room and no need for discussion. But at the next levels (2^{nd} to 6^{th}), the discussion maybe helpful; the higher cognitive level, the more efficient is the discussion as a learning method. “Discussion is a high versatile strategy that can be used not only to help students develop problem-solving skills and to share opinions but also to attain subject matter mastery" (Gall and Gillett, 1980, p. 98). Therefore, discussion is recognized to be "a key component" of online students' learning (Ertmer et al. 2007).

This notion relies on constructivist ideas on learning and teaching. Both Piagetian and Vygotskian constructivist theories "emphasise the learner taking an active role in the learning process rather than being a passive recipient of knowledge from the teacher" (Thomas, 2013); it is the learner who constructs his knowledge.

There are two main forms of online discussion: synchronous online discussion (SOD) and asynchronous online discussion (AOD). The latter has attracted more researchers' interest.

"An asynchronous online discussion forum may be defined as a text-based computer-mediated communication environment that allows individuals to interact with one another without the constraint of time and place" (Hew, Cheung and Ling Ng, 2010). The authors explain that AOD is regarded to be more beneficial to student learning because:

- all the messages are kept in their original, chronological sequence;
- all the messages are available to all the participants;
- students can view the messages many times and analyse them;
- students can contribute at their own pace;
- students have more time to construct their ideas and to verbalise them what is beneficial to "higher-level learning".

Therefore the AOD "supports student understanding of concepts (…) allows students to share, compare, analyse, criticise, supplement, and apply information from others (…). It promotes group construction of knowledge while fostering individual assimilation and retention" (Baker, 2013).

1. RESEARCH ON ASYNCHRONOUS ONLINE DISCUSSION

Research on processes and phenomena in the scope of online discussion forum date back to the last decade of the second millennium and explore complex preconditions of a productive and satisfying students' participation.

Asia and Europe are world leaders in AOD research, while Singapore, Taiwan, and the U.S. have the *largest numbers of publications* in the field.

In Poland, research papers on the use of asynchronous online discussion are still few. Evidence from Polish research studies shows a minor interest for this type of LMS teaching/learning tools declared by university teaching staff (Chmielewski et al., 2013; Redlarski and Garnik, 2014; Niksa-Rynkiewicz, 2017). But this is about to change soon.

The new "Constitution for Science" introduces doctoral schools as the unique path to academic career and sets higher standards for university teachers' teaching skills. That is why we have to analyse foreign approaches to teaching and learning and to evaluate them.

Systematic reviews of research literature on AOD (Hammond, 2005; Johnson, 2006; Andersen, 2009; Roehm and Bonnell 2009; Hew et al., 2009; Gao et al., 2013; Loncar, Barrett and Liu, 2014; Thomas, 2017) show that the greatest number of studies focuses on student learning effectiveness in asynchronous online discussion environments.

One of the most fundamental conditions of the AOD effectiveness is student participation and engagement resulting in a contribution to the discussion (measured in the number of postings). In his paper published in 1997, Mark Guzdial found that per 18 classes he investigated at Georgia Tech, "the average discussion thread contained only 2.2 messages, which was essentially a single message and a response to that message" (Hew et al., 2007). Similar *research* findings were obtained by other authors. Hewitt observed that limited student contribution in asynchronous online discussions "appears to be a persistent and widespread problem" (2005).

Khe Foon Hew and co-authors (2007) suggest that limited student contribution has its primary causes in student himself (personality traits, lack of motivation, lack of critical thinking skills, discouraging behaviour of other participants, etc.).

Other authors do not *maintain* this proposition, *focussing rather* |*on "external* factors" influencing student engagement. The most important "external factors" are related to teacher (moderator, facilitator) and other co-participants:

- design of AOD environments (Gilbert and Dabbagh, 2005; Gao, Zhang and Franklin, 2013; Echeverria, Cobos and Morales, 2013; Yilmaz and Yurdugul, 2016),
- teacher role, his teaching skills and engagement (Goodyear et al., 2001; Goodyear, 2002; Mazzolini and Maddison, 2003; Liu et al., 2005; Guldberg and Pilkington, 2007; de Laat et al., 2007; Wang, 2008; Berge, 2008; An, Shin and Lim, 2009),
- other students engagement and group influence (Wasko and Faraj, 2000; Fung, 2004; Brewer and Klein, 2006; Dooley and Wickersham, 2007; Liu and Tsai, 2008; Chan, J.C.C.; Hew, K.F.; Cheung, 2009; Young and Bruce, 2011),
- student engagement with problem content and knowledge construction (Perkins and Murphy, 2006; Putman, Ford and Tancock, 2012; Hull and Saxon, 2009; Lan et al., 2012; de Leng et al., 2009).

A limited student contribution in asynchronous online discussions is not the main topic of this paper. Nevertheless, the first two of the four above-listed points have drawn our attention. From pedagogical point of view a limited student contribution may be regarded as a result of teacher negligence in "design of AOD environments", and inadequate teacher moderation caused by lacking teaching skills and commitment. Discussion (including online discussion) is one of teaching/learning methods – ways in which the aims of education may be achieved – and as such needs proper preparation and moderation. This paper aims to emphasise the teacher's role in the student's successful learning within online settings.

2. DISCUSSION AS A TEACHING/LEARNING METHOD

It was John Dewey who conceptualized discussion as a problem-solving, activating method (Petty, 2014). What is the discussion? According to Polish authors, the discussion is a method that involves "mutual exchange of thoughts and opinions while students work together on a certain issue covered by the curriculum. Not only does the discussion enable problem-solving by adding together the knowledge of respective participants, but it also allows verification of hypotheses and confrontation of various positions and opinions (Bereźnicki 2001, p. 284). In general, educators agree that discussion as a teaching method belongs to the group of methods appealing to the human cognitive sphere. The classical division of teaching methods (Okoń 1998, Bereźnicki 2001, Bereźnicki 2015), where the criterion is the dominant type of activity in a teaching-learning situation, identifies: knowledge assimilation methods (based on reproductive cognitive activity), self-acquisition of knowledge methods (based on productive cognitive activity), evaluation methods (where emotional activity is dominant) and practical methods (characterized by engagement in the practical and technical spheres). According to some authors, discussion belongs to methods relying on information transfer (Okoń 1998, p. 256-257), because its main goal is to exchange opinions.

Joyce, Calhoun, Hopkins (1997) tend to classify discussion as a social model. The authors use the concept of a model because, in their opinion, the trigger of a given sequence of teacher's activities, which is a sequence of teaching activities is the desired model, the pattern of learning. The teaching-learning method, the educational strategy or procedure, is thus a construct that governs the teacher's conduct, based on the scheme of a certain type of learning. The proposed division is by no means an exhaustive description of separate sets. The models may be complementary and intertwined. Based on the criterion of the type of thinking triggered by applying a given strategy or method and the pupil's place in a model, the authors divided the models into four groups: information processing models (the processual and cognitive type), social modes (whose task is to create a community of learners), personality development models and behavioural models. The thing that the social models have in common is that they create a community of learners - a specific community that generates collective energy called synergy, which, rather than being a simple accumulation of the energies of the respective community members, is its multiplication and facilitates the learning process. All the ideas for various forms of group work are based on the pedagogically proven advantages of learning together. Social models, on the one hand, may serve the purpose of achieving certain, strictly cognitive results (promoting specific types of thinking, solving cognitive problems together, confronting a different - individual or group – perception of a given issue), but, on the other hand, they may stimulate social interactions and build group standards and contracts that, in the first place, enable good collaboration. These models promote pro-social attitudes and readiness to support one another, they help develop democratic decision-making procedures, and enable learning through collaboration, which is a chance for students to develop the skills of negotiating, discussing and listening to one another, managing one’s own work and the work of others, accepting responsibilities based on group decisions and, last but not least, learning from one another.

Thus, discussion as a teaching method may be analysed from two perspectives: on the one hand, it may strongly engage the human cognitive sphere, it may trigger advanced processual and cognitive learning patterns that focus on creative problem solving; but, on the other hand, the main goals of a group discussion may be social, focusing on the development of important social skills: listening to one another with understanding, building arguments and counterarguments to support a given position and the ability to change the cognitive perspective to an emphatic “insight”, stepping into the phenomenological field of another person by accepting the world of their experiences.

2.1. Other contexts for the discussion method

Transcending the constructivist context (both Piagetian and Vygotskyan) focussed on the intellectual-cognitive sphere of human personality, we can find other interesting contexts; for example, an aesthetical one. Educational hermeneutics, especially in art, literature, or music goes far beyond the acquisition of information. Discussion is a good method to form and develop aesthetic standards and sensibilities. It is indispensable in acquiring and cultivating students’ analytical and interpretational skills. In this regard, the discussion should be more sharing- than fighting-like.

Similar effects may be expected in the context of practical skills from craft, dance, sport to actor’s craft and music as performance art. In this context, taking part and taking advantage of the essential discussion assumes a certain degree of proficiency. The members of the discussion group or forum should not represent highly unequal skill-levels (Neville).

Social constructionist approach to emotions (Rom Harré and James R. Averill) is different from the approach presented by sociologists recalling Émile

Durkheim's thought. The main difference lays in the conceptualisation of the role of collective (rather than individual) interpretation in the social causation of emotions (Fisher and Chon, 1989, p. 1). Assuming that emotions (at least to a certain extent) are socially constructed and emotional reactions to typical social phenomena are negotiated within smaller and larger groups, we discover another context in which discussion has to be recognized as a learning method. Discussion enforces verbalization of many undiscerned and poorly recognized elements of human experience, becoming an important factor to management and cultivation of emotions.

One other context to be noted is the so-called "humanistic approach" to education relying on Abraham Maslow's psychological theory, developed in the theory and practice of psychotherapy by Carl R. Rogers. PCA (Person-Centered Approach) focusses mainly on the internal functioning of human persons. Rogers argues that learning problems have their sources in internal dysfunctions. The climate of acceptance, understanding, and authenticity fosters "internal healing" and overcoming of individual problems, opening the space for natural creativity. Discussions focussed on interpersonal climate and relationships, concerning acceptance, understanding, and authenticity of group members help satisfy important psychical needs of students and breaking communication barriers (Kościelniak, 2004). This is one of the main preconditions of effective learning.

Online discussion may serve a variety of educational purposes. When the purpose differs, effective environment for interaction and discussion varies. Fei Gao, Tianyi Zhang, and Teresa Franklin (2013) identified four educational purposes that are crucial to successful student learning in online forum discussions:

- fostering an online community,
- "a community of learners, which represents the ideal discussion forum environment, is one in which students embrace a sense of belonging, support each other, develop shared values and enjoy their shared identity" (Maher Palenque and DeCosta, 2015, p. 85),
- encouraging information sharing,
- people do not learn in isolation, but through interaction; a larger and deeper knowledge of individuals is socially constructed,
- promoting critical thinking,
- "conflicting perspectives of students should be carefully examined and developed (…) Learning takes place when students re-examine their original positions on an issue and explore new resolutions" (Maher Palenque and DeCosta, 2015, p. 85). Deeply held beliefs and the origins of those beliefs should be examined,
- supporting collaborative problem solving,

- productive discussions focus on new information drawing on prior knowledge. Student comprehension should be facilitated through intentional questioning to help binding new information to what student already knows. The best way to do this is fostering peer-facilitation.

2.2. The role of discussion within the teaching/ learning process

Despite its relevant potential, the discussion is neither self-sufficient nor universal method, and its educational meaning and efficacy depend on its role in the teaching/learning process and cooperation with other methods.

In his „Practical Guide" to discussion method teaching William M. Welty says: "If you seek to encourage true discussion, you cannot do it by having a discussion here and a discussion there - it has to be a regular and substantial part of the course" (1989, p. 204). The same refers to a single class in face-to-face settings and a single unit of an online course (including modern LAMS - Learning Activity Management System).

3. PREPARATION FOR GROUP DISCUSSION IN THE FACE-TO-FACE AND ONLINE SETTINGS – PRINCIPAL STAGES

Preparation is, in fact, the first but inexplicit, almost "hidden" stage of educational discussion. Numerous research studies confirm that proper preparation of teacher and students is crucial to discussion resulting in operational knowledge acquisition. Thirty years ago Feldman's research showed "the dimensions of teaching that are the strongest correlates of student achievement: (1) preparation and organization; (2) clarity of communication; (3) perceived the outcome of the instruction; and (4) stimulating student interest in the course content. The first two concern the organization of information and its effective presentation and have traditionally been part of a teacher's preparation. The second two deal with motivation and engaging students in their learning" (Theall, Wager, and Svinicki, 2019). "If we want to find ways to help students to internalize the theory" (…) "preparation for a discussion class needs to marry content and process" (Welty, 1989, p. 201). The author implies that "the teacher (…) must be ready for almost any nuance to be discovered, for almost any connection to be made" (ibid.). A meticulously structured outline of important concepts should be prepared because "important concepts usually have somewhat important sub-concepts, (…) and several layers deep in important concepts" (Ibid.).

Only after completing this part of his preparation, the teacher will be ready to decide on contents for students. This is also the right moment to decide on teaching/learning methods that will help students to master the selected contents. There is a large variety of teaching and learning methods and strategies. It is wise to take account of student preferences, which may differ from group to group. Some groups prefer to read assigned texts before the discussion begins.

Some groups prefer, for example, to hear (and watch) multimedia supported lecture and to ask questions until the subject matter is crystal clear to them. From the teacher point of view, the chosen method/methods should be effective – no matter if it is a direct or indirect one. Here we meet another advice from Welty's "Practical Guide": "Before every class, look over your roster and update your knowledge of each student" (Ibid., p. 203).

The key condition of a successful discussion is the proper preparation of teacher and students. How to assure student preparation? How to motivate students to study and to understand the theory they need to grasp? From the present authors' experience, in most cases, achievement, incentive, or competence motivation is more efficient than fear or power motivation.

In the constructivist context, especially within the Piagetian approach, "an incentive," which can activate student's cognitive processes may be understood as a kind of 'perturbation' in student's cognitive structures. The teacher may do it by providing the student with educational resources rich in elements that may act as cognitive 'perturbations'; placing the student in a physical or social environment (or physical and social) that satisfy the same conditions; deliberately presenting the student with 'challenges, novelty and opportunities to learn' taking into account individual cognitive needs and preferences. Facilitation of the student's cognitive processes may be conceptualized as an attempt to restore the disturbed cognitive equilibrium (Sajdak and Kościelniak, 2013).

And here are some more of Welty's pieces of advice: "Once you are sure of your grasp of the facts, prepare a question outline to match your concept outline (…). Ask questions and more questions and still more questions. If you hear yourself making too many declarative statements, the discussion is not going well" (1989, pp. 201-202).

Resuming, it is not enough that preparation-work makes the teacher a Subject-Matter Expert. It has to make him also a "Student-Potential Expert".

4. STARTING A DISCUSSION FORUM

One of the most important things determining the success of a discussion forum is understanding the goal. Otherwise, the popular saying: "if you do not know where you are going, you will get somewhere else without even knowing it" will become painfully true.

Polish authors usually distinguish three key stages of a discussion: (1) opening and introduction; (2) discussion; (3) recapitulation of the results and closing down (Bereźnicki 2001, p. 285). Our focus is on the first and the third stage.

Before we go to the first stage, it is worth mentioning that in an asynchronous activity, which a discussion forum is, there is no time or space to correct or clarify what one has said in response to the slightest (also non-verbal) signs of not being understood by other members of the discussion group. A post once published starts to live its own life, and even though it may be clarified, explained, or asked about, there will always be a shift in time. Thus, it is vital to know the importance of the goal of a forum and to formulate a relevant question to encourage a discussion.

Preparation work well done by the teacher and students, an online discussion forum can be opened easily – with one single question which works like a burning match setting fire to properly prepared campfire.

Let's stop here for a moment. Even the best preparation and the best discussion outline is not enough unless we cannot stay open to the ongoing situation.

An exemplary situation. A teacher opens discussion asking students: *What do you think of the possibility of opening all forms of university classes and make them optional?*

This specific question was asked to initiate and encourage discussion on more general educational problems, but instead triggered a heated discussion on the values of freedom and responsibility. Finally, students, together with the teacher, decided that attendance at the classes during the whole course will not be checked. The result - almost 100% course attendance (face-to-face and online). That was a nice surprise, although most of the teacher's preparation work turned out to be useless.

The story was mentioned to introduce a "golden thought" concerning educational discussion consisting of only one word – flexibility.

5. MODERATING A DISCUSSION FORUM

Online forum moderation/facilitation requires much attention and activity on the part of the teacher. One can fall into the extreme and, for example, start a forum and then remove from it and leave the discussion to itself, or, to the contrary, follow the posts meticulously and answer almost every single one of them. Both options bear an error and lead a discussion to failure either because of being neglected or because of excessive control.

The online forum researchers and practitioners agree that the moderator's role is a complex one. David L. Baker distinguishes four moderator's roles: **pedagogical** (planning and organizing, introducing AOD, using groups, setting boundaries), **social** (creating comfort, promoting cohesiveness, preserving presence, guiding netiquette), **managerial** (enforcing boundaries, employing icebreakers, assessing performance, handling dysfunction), and **technical** (**e**stablishing transparency, aiding learning curve, supporting technology, preparing for contingencies). (2013, p. 19).

The author admits that his review "has limitations". Still, it provides us with better insight into the forum moderator's role complexity. Teacher moderating an online discussion forum must know his roles and tasks. He should know what kind of work can be done by students themselves and what kind of work – cannot and should not.

Very similar teacher/moderator's roles we can find in Baran, Correia and Thompson study: managerial and instructional design, pedagogical, technical, facilitator, social (2011, p. 433). In their research study, Nandi, Hamilton and Harland assign typical teacher activities to these roles:

'Managerial and instructional design
- providing administrative guideline
- declaring expectations

Pedagogical
- clarifying questions and problems
- periodic intervention to direct and extend discussion
- promoting deep learning
- raising new questions

Technical
- proving technical assistance

Facilitator
- providing direct answers
- providing feedback (+ with examples)

Social roles
- initiatives for community building' (2012, p. 26; Table 6. Ideal roles of an instructor and how to implement them).

6. CLOSING DOWN THE DISCUSSION FORUM

The average duration of a forum hasn't been experimentally determined. Within the present authors' experience it was 24 days, but some of the forums lived even for 64 days.

Most practitioners recommend intentional closing down of a forum, e.g., with a post that summarizes the topics discussed or the opinions expressed, a post thanking all the participants for their activity, or a post inviting to a new project or another meeting in a virtual or real space of the university. After such a post, students should be allowed to express their final thoughts or ask questions, and the moderator should once again say goodbye to all.

7. THE AUTHORS' RESEARCH

We have verified two models of moderator's roles in online discussion; the one presented by David L. Baker (2013) and the other by Baran and Coreia (2011).

We were able to undertake such a verification thanks to collected and saved data from online courses led by Anna Sajdak Burska. From 2009 to 2017 Professor Sajdak-Burska led 37 b-learning courses for tertiary and post-graduate students at Jagiellonian University (Cracow, Poland). An approximate number of students involved was 750. Jagiellonian University uses Moodle LMS (almost 5,5 thousand active online courses per year). Instructors have access to several tools and reports that can be used to assess student performance. All the relevant data of online courses (outline reports, complete reports, today's logs, all logs, including teacher activities) were collected and preserved for research purposes. The preserved data of Anna Sajdak Burska's online courses were analysed using the IBM SPSS Statistics 25.0.

The first stage of the quantitative analysis *was undertaken* regarding a set of categories of forum moderator's role assumed by Baker (2013) and Baran and Coreia (2011). The analysed research data fulfilled all the assumed categories but did not consume all the research data – some data were "left over".

The interpretation of these research findings led us to an extended model of the moderator's role in the online discussion forum. Research evidence led us to a conclusion that the moderator's sub-roles should be differentiated according to a criterion, which is moderator focus. In our research study, the moderator was focussed on:

- individual student learning, group and sub-group learning in the problem-solving process (38,5%)
- the discussion itself (opening and closing, student participation, misleading threads, excessively exploited threads, deserted threads, "traffic jams", break-downs, etc.) (23,6%)
- group climate (15,5%)
- motivation (13,4%)
- other (9%)

Within our model of the moderator's role, there is no room for preparatory work. It belongs rather to the teacher's/instructor's role. Moderator's activities within sub-roles are more similar to those we know from Baker (2013), Baran and Correia (2011), Gao, Franklin, and Zhang (2013), Nandi, Hamilton and Harland (2012), or any other research papers.

1. Individual student learning, group and sub-group learning in problem-solving process

- Asking and answering questions
- Clarifying questions and problems
- Providing extra learning materials
- Consulting
- Providing feedback

2. Discussion itself
   - Monitoring performance
   - Assessing performance
   - Setting and enforcing boundaries
   - Closing down threads
   - Opening new threads
   - Releasing “traffic jams”
   - Preserving visible presence (Baker, 2010)
3. Group climate
   - Monitoring emotional quality
   - Providing emotional support
   - Mediating
   - Restoring a good climate
4. Motivation
   - Encouraging
   - Providing incentives
   - Recalling individual interests
   - Underlining student knowledge and skills
   - Reaffirming student self-worth
5. Other
   - Explaining moderator’s and students’ posts
   - Repeating explanations
   - Solving student problems loosely connected with the forum (“by-the-way-problems”).

The present authors’ model should be regarded as a hypothetical one. Nevertheless, it confirms a more general notion concerning the need for such concepts and reliability of their construction.

In our study, the number of posts contributed by students and the duration of the forum may be regarded as a quantitative confirmation of the reliability of the effectiveness of the assumed teacher activity model. Table 1. shows the number of posts and duration of the forum in two cycles of online courses led by Anna Sajdak Burska.

Table 1.

Number of posts and duration of the forum - cycles I and II

Cycle 1. Forum no.	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
Number of posts	13	7	10	10	43	14	44	38	18	19
Duration of the forum (days)	32	16	30	5	64	34	29	65	36	40
Cycle I Forum no.	**F11**	**F12**	**F13**	**F14**	**F15**	**F16**	**F17**	**F18**	**F19**	**F20**
Number of posts	8	7	16	23	23	25	18	29	10	14
Duration of the forum (days)	17	5	24	28	25	45	37	33	26	30
Cycle II Forum no.	**F21**	**F22**	**F23**	**F24**	**F25**	**F26**	**F27**	**F28**	**F29**	**F30**
Number of posts	16	7	17	19	10	22	15	13	27	26
Duration of the forum (days)	14	9	15	7	7	14	12	18	32	28
Cycle II Forum no.	**F31**	**F32**	**F33**	**F34**	**F35**					
Number of posts	21	18	13	18	24					
Duration of the forum (days)	15	13	12	16	15					

Source: Own work based on the authors' research.

The statistical average of the number of posts in a forum was approximately 19, but the actual number differed between 7 and 43 posts per forum.

8. THE FUTURE OF THE ONLINE DISCUSSION FORUM

Designing an online discussion forum requires not only pedagogical, managerial, social, and technical competences. It also requires a lot of professional experience. As well as moderating such a forum. There is no doubt that the variable, which is the professional experience of the teacher makes a difference in results from research studies on online discussion fora. This paper, like many other papers concerning online discussion forum, confirms the general conclusion that despite differences in existing studies we have already enough research evidence to create comprehensive models of teacher roles in designing and moderating online discussion fora and to develop these models identifying adequate and more detailed analytical categories.

That means we have already a theoretical base to create computer programs to support the teacher in designing not only online fora, but also the whole online, b-learning, and face-to-face courses. Engineers working in many disciplines have their CAD systems (Computer Assisted Design). Why not the teachers? There are economic reasons behind it, yet there are no scientifically justified reasons.

Monitoring relevant variables in discussion forum processes do not require very sophisticated software. A properly designed computer program could provide the teacher with important feedback. And a CAD for teachers cannot be more expensive than investments in "teacher quality".

Science-fiction? Why? A lot of concepts were science-fiction ideas in their beginnings.

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TEACHING SKILLS IN THE AREA OF TERMINOLOGY AND TERMINOGRAPHIC MODELLING VIA E-LEARNING AS PART OF TRANSLATOR TRAINING PROGRAMMES

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Abstract: *The increasing importance of translation training in academic programmes, arising from the growing requirements of the modern translation market with respect to translator skills and competences, renders it necessary to nclude elements of terminology and terminographic modelling in the study curricula. Rapid development of computer software provides numerous opportunities in this respect. The authors of the study present a methodological concept for teaching basics of terminographic modelling through self-study with the use of commonly available e-learning infrastructure (Moodle) and computer-assisted translation tools (memoQ). Conclusions provide guidance for the implementation of terminology and terminography in academic programmes and open avenues for further development in this area.*

Keywords: terminology, e-learning, computer-assisted translation, translator training.

INTRODUCTION

Teaching translation is, no doubt, one of the most popular and robust areas of applied linguistics at the moment. The rapid growth of the global translation market, ever faster development of new translation technologies and continuous specialisation in almost all professions and disciplines put a considerable amount of pressure on universities to furnish up-to-date, comprehensive translation programmes as part of their study curricula. That is, by no means, an easy task given the abundance of requirements and expectations of the modern marketplace. The issue is further complicated by the multitude of competences which contemporary translators are expected to wield including, among others, linguistic skills, cultural awareness, information mining ability, communicative competence, social and interpersonal proficiency, computer skills, textual competence and knowledge of a particular industry which is necessary for translating languages for special purposes (LSP). The above requirements stem directly from worldwide industry standards such as ISO norms or ASTM guidelines (cf. ISO 17100 Translation services — Requirements for translation services, F2575-06 ASTM Standard guide for quality assurance in translation, GB/T 19363 1-2003 Specification for translation service — Part 1 Translation (National Standard of the People's Republic of China), EN 15038:2006Translation services — Service requirements and more) and have, to a large extent, made their way into the study outcomes established under the Bologna Process. Among the various skills and abilities which need to be conveyed to future translators and interpreters are, however, also such competences which cannot be straightforwardly aligned with any classification (inasmuch as no such classification may ever be considered final and ultimately exhaustive) as they are interdisciplinary and therefore negotiate the boundaries between traditionally understood disciplines. A good example of such interdisciplinary competences are knowledge and skills in the area of terminology which constitute the topic of this study.

1. TERMINOLOGY WORK AS A REQUIREMENT

To begin with, it is beyond any doubt that terminology is a vital component of the modern translation paradigm, in particular as regards LSP translation. A glance at the earlier-mentioned quality standards instantly reveals that the word "terminology" appears on numerous occasions all throughout the text of both sets of guidelines. For example, the current ISO 17100 standard mentions terminology in clause 3.1.3. "Professional competences of translators" under pt. (d) *cultural competence* ("ability to make use of up-to-date terminology" and pt. (f) *domain competence* ("ability to understand content produced in the source language and to reproduce it in the target language using the appropriate style and terminology"), clause 3.2 "Technical and technological resources" under pt. (d) ("terminology management systems"), clause 4.6.3 "Linguistic specification" ("use of appropriate terminology"), clause 5.3.1 "Translation process" under pt. (a) ("compliance with specific domain and client terminology") and also in Annex D "Pre-production tasks" under pt. (e) ("collection and preparation of reference materials") (ISO 17100 Translation services — Requirements for translation services). References to terminology are equally abundant in the ASTM Standard guide for quality assurance in translation whose entire chapter 3 is dedicated to the various aspects of this issue and its impact on the quality of translation (F2575-06 ASTM Standard guide for quality assurance in translation). However, while it seems clear that terminology is, in fact, a vital component of the translation reality, it is by no means equally clear as to what the notion actually signifies.

1.1. Towards an understanding of terminology

The word "terminology" usually brings to mind a set of specialised words or expressions which belong to a specific domain and are used to describe a small portion of our surrounding reality. A simple query in the Longman Dictionary of Contemporary English yields the following entry: terminology means "technical words or expressions that are used in a particular subject" (retrieved on 25.07.19). A more linguistically-inclined (and precise) definition states that "A terminology is a set of terms representing the system of concepts of a particular subject field" (Sonneveld and Loening 1993). While entirely correct, this definition only covers one part of the meaning of the term. For the purpose of this study, however, a broader perspective is necessary, i.e. one that treats terminology also as a branch of knowledge and a field of professional activity. According to Cabré (1998), terminology is a "discipline concerned with the study and compilation of specialised terms." As such, it appeared at the beginning of the 20th century as a response to the rapid proliferation of specialised terms resulting from the dynamic technological development of that time. Notably, the pioneers of terminology as a field of study were not usually scientists, but rather subject field experts, including Eugen Wüster who is considered to be the founder of modern terminology and head representative of the so-called Vienna School. It was only in the second half of the 20th century that linguists became interested in terminology alongside technicians and from that moment onwards the discipline started to fall into two separate categories, that is theoretical and applied terminology. A general theory of terminology is based on an approach which gives major importance to the nature of concepts, relations between them and the relationships between terms and concepts as well as to assigning terms to concepts (Cabré 1998). From a practical, or applied perspective, terminology is understood as the process of compiling, describing, processing and presenting terms of special subject fields (Cabré 1998, 10). Lukszyn (2006) brings these two perspectives together arguing that the fundamental goals of terminology as an interdisciplinary study include analysing the functioning of specialised vocabulary, developing more efficient ways of constructing new terminological systems and improving the already existing ones (Lukszyn, Zmarzer 2006). For the avoidance of doubt, the above does not serve to argue that terminology is a fully independent scientific discipline. In fact, some of the outstanding representatives of the field claim it most certainly is not. According to Sager (1990):

There is no substantial body of literature which could support the proclamation of terminology as a separate discipline and there is not likely to be. Everything of import that can be said about terminology is more appropriately said in the context of linguistics or information science or computational linguistics. We see terminology as a number of practices that have evolved around the creation of terms, their collection and explication and finally their presentation in various printed and electronic media (Sager 1990).

Lukszyn (2006) offers an elegant solution arguing that due to the fact that the subject matter of terminological research are specialised terms falling within the scope of various branches of knowledge, terminology itself is formally tied to all the other scientific disciplines and areas of practical activity. That, in turn, is reflected in the vast number of terminological dictionaries compiled worldwide and therefore, since the preparation of a terminological dictionary requires not only the knowledge of a certain industry-specific set of vocabulary, but also the principles and techniques of terminological activity (specialised knowledge), terminology should, from this perspective, be seen as "an auxiliary discipline with respect to other branches of knowledge and activity" (Lukszyn 2006). The researcher therefore does qualify terminology as a legitimate discipline with its own methodology, but at the same time renders it closely connected with, and indeed supplementary towards, other branches of knowledge. Notwithstanding the above, whether terminology is perceived as an independent science or an interdisciplinary methodology, it is against the aforementioned backdrop that it should be understood from the perspective of its significance for (albeit not only) translation, i.e. as the study of specialised vocabulary, the way it functions and the way it should be handled in the most efficient manner. More recently, the above catalogue was extended to include standardisation as an important component of terminological activity (Grattidge, Westbrook 1993, 9-21). It is of vital importance to realise that all of the aforementioned facets must be taken into account in order to properly understand the meaning of the word terminology as it is used in relation to translation.

2. THE STUDY OF TERMINOLOGY FROM THE PERSPECTIVE OF A TRANSLATOR

As mentioned above, describing, studying, classifying and otherwise handling specialised vocabulary is frequently referred to using the umbrella term of terminological activity. One of the key propositions of this article is that translators (in particular those working with LSP material) frequently perform terminological activity in their work. Aa mentioned above, while "a terminology" denotes a structured set of specialised vocabulary belonging to a given subject field, "terminology" as a field of academic and practical activity involves studying, describing, classifying and standardising such specialised vocabulary in line with certain rules and criteria. According to the above, placing specialised vocabulary in a data base would surely qualify as terminological activity as it requires the application of appropriate taxonomy, furnishing adequate and meaningful descriptions (definitions) and arranging lexical items according to a certain scheme (so-called macro- and microstructure). A data base must therefore have a structure, an internal network of relations between the individual units and a system for locating those units within the entire resource. That, in turn, seems in line with the main assumptions of the study of terminological lexicography which is a branch of lexicography dealing with the theory and practice of developing terminological dictionaries (Karpiński 2008, 6) and, from another perspective, the art of terminography which is understood as the comprehensive methodology for the preparation of appropriate information concerning concepts and networks of concepts within a particular subject field (ibidem).

2.1. Terminological activity in computer-assisted translation

Handling terminology in the manner described above is, no doubt, an integral component of computer-assisted translation. CAT tools are becoming more and more widespread in the translation industry which is due to their availability and the fact that they have been largely adopted by professional translation agencies as the main tool for the rendition of translation services. These programs possess an extremely wide array of functionalities covering the entire spectrum of activities constituting a translation project (Szwed 2017, 234) and are used by translators, project managers, editors and proof readers alike. One of the key functionalities of every professional CAT tool is a special data base for keeping and retrieving terminology which is manually fed by the software user and which subsequently recognises and suggests equivalent terms during the translation process, as depicted in Figure 1.

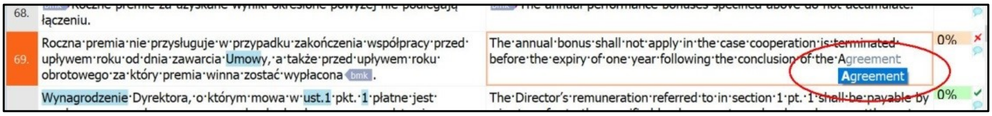


Figure 1. Automatic terminology retrieval from a database.
Source: Own work

In order to input new terminology for later use, a translator must manually update the data base in the program which is usually possible in a number of ways, however most commonly it requires selecting the source item and the target language equivalent and, subsequently, filling in the basic information about the new entry which facilitates later retrieval. This type of simplified input interface is presented in Figure 2 below.

As shown above, it is a very simple procedure which, in its basic form, requires no more than indicating the source and target item and confirming the selection with the "OK" button for the entry to be operational. Updating the entry with additional information, such as a definition, examples of use, grammatical information, entry identifier, project, domain, client or author information as well as additional descriptions or even an image or a photograph is not obligatory. This is, of course, a very limited form of using a resource which is otherwise significantly more complex. However, most translators choose to take advantage of the term base in this particular way, foregoing the benefits arising from the more advanced functionalities of the resource. However, as a term base comprises a set of lexical items functioning (as the case may be) within a terminological macrosystem (Michałowski 2017, 21), it may either be seen as a simple glossary or assuming a more structured manner of processing the input material is applied, a proper terminological dictionary. Since most translators do, in fact, use the term base only as a simple glossary (i.e. without any structured processing of the lexical material), this mode of use deprives them of the various benefits offered by this resource limiting its functionality to maintaining lexical consistency in the translated document (Szwed 2018, 169). The benefits of using an active term base in a CAT tool are, no doubt, considerable – even if its structure is maintained on the minimum level of complexity (which, among others, guarantees smooth and expedient work). However, as the program does not restrict the number of term bases used with one project at a time, it is possible to operate a number of different term bases simultaneously – the fundamental differentiation between them being the manner of processing the lexical items in particular.

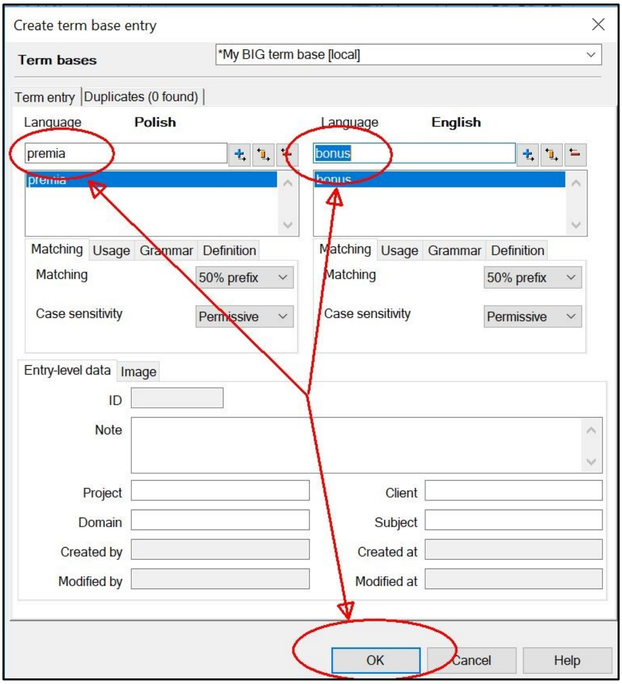


Figure 2. Creating a new term base entry with simple description.
Source: own work

Having made the claim that a CAT tool term base may, in fact, serve as a fully functional terminological dictionary, it seems justified to briefly recount the basic prerequisites which allow for such a classification. According to Lukszyn (2006), a terminological dictionary differs from a general language dictionary in that its entries are treated as units functioning within a certain cognitive paradigm which emphasises the relationships between the individual items (Lukszyn 2006). Furthermore, a terminological dictionary must be characterised by a certain macrostructure and a specific microstructure. The former denotes the general limitations of the structure of the dictionary, including the principle whereby the contents of the dictionary should be based on a representative corpus of authentic texts containing up-to-date terminology used by professionals in the given field (Michałowski 2017), while the latter represents the specific realisation of the general principles which lay at its foundation, including, in particular, the choice of specific strategies for the description of the input material. It would appear that the functionalities of term bases embedded in modern CAT tools allow for the realisation of both the aforementioned parameters. The fact that it is possible to connect multiple term bases to a single project means that a translator is able to freely shape the general structure of each such base depending on the desired level of terminographic description and its place within the terminological macrosystem (ibid.). The point of departure here might be the fact that a typical terminological lexicon, that is a set of specialised lexical items representing the current state of professional knowledge within a given, specific field (STP 2002), contains up to around 2000 units (Lukszyn 2006). Furthermore, the numerous categories of description of lexical items available in the term base interface give the user considerable control over the microstructure of the base, as seen in Figure 3 below.

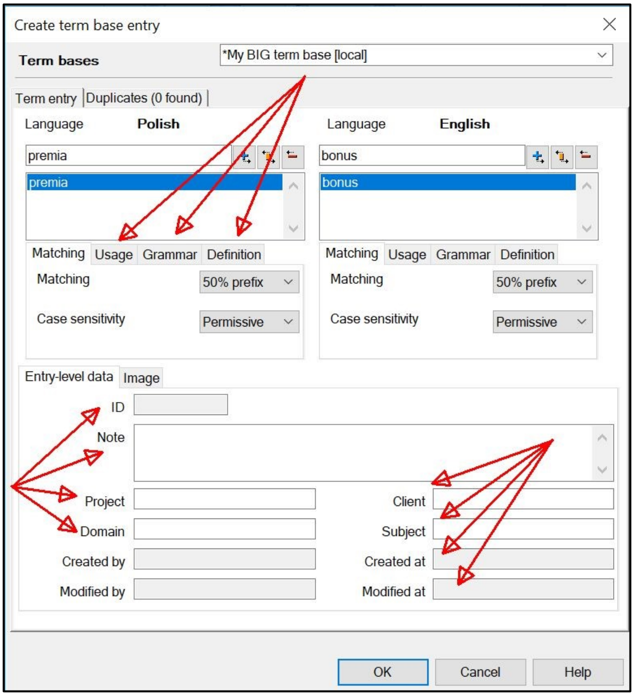


Figure 3. Creating a new term base entry with advanced description.
Source: own work

Therefore, it is possible to arrive at a term base which will not only be representative of the given field of knowledge and adequately adjusted to the specific terminological lexicon which reflects its contents, but also structured and systematic in a manner which allows it to function as a proper terminological dictionary. Generally speaking, the key is to properly estimate the number of lexical units, specify the type of dictionaries to be represented and choose the manner in which the particular elements of description are recorded (Karpiński 2017). It seems that all (or most) of the above are possible using the term base functionalities offered by modern CAT tools. That said, it would seem clear that the assumption whereby contemporary translators using professional computer-assisted translation software do, in fact, perform terminological activity, is by all means true.

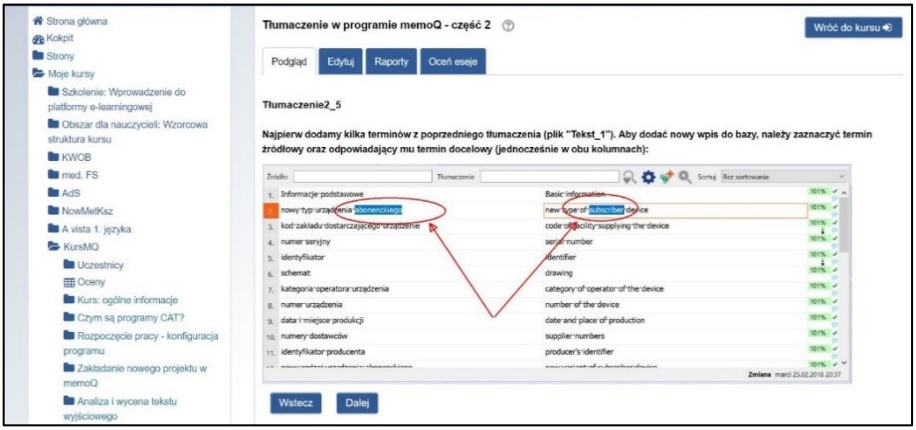
3. TEACHING TERMINOLOGY WORK

In order to take note of the fact that the work of contemporary translators requires some form of terminological activity and, as a result, being able to perform that activity should be treated as a valid component of the translation competence (it appears that the requirements stipulated under currently applicable quality standards are also pointing in that direction), we designed an e-learning course for the purpose of teaching the basics of computer-assisted translation with the use of one of the leading CAT tools on the market (Kilgray's memoQ). This particular product was selected due to its very good performance, comprehensive functionality, modern interface and considerable popularity on the translation market (in fact it is one of the two most popular CAT tools in Europe – aside from SDL Trados Studio). While there are also free CAT applications available on the market (in most cases as on-line tools), their functionality is significantly limited and often does not include the desired terminology management features (and where it does, their terminology data bases are simplified and do not offer the possibilities discussed in this paper, which determine the core value of terminology training via e-learning infrastructure). The course utilises the open-source Moodle platform and is available on the website of the Maria Curie Skłodowska University known as "Wirtualny Kampus" (Eng. *Virtual Campus*). It currently consists of 10 sections and includes topics such as the basics of CAT tools, software configuration, setting up projects, analysis and pricing of translation jobs, using the translation editor with its various functions, including translation memories, filters and pre-translation tools, exporting target files, handling term bases and using quality assurance functionalities. The course also contains glossaries of key terms, feedback questionnaires for participants and discussion forums for responding to questions or doubts as to its particular features. Furthermore, throughout the course students are required to perform homework tasks on their own computers (we secured an appropriate number of memoQ licences from the software's manufacturer to distribute among students for the purpose of individual work during the course) and upload them to the platform for evaluation. The part of the course which deals with term base management covers issues such as setting up new term bases, various ways of feeding new terms into the base such as manual addition of terms during translation, feeding glossaries in Excel format and using terminology extraction tools, properly describing terminology entries and creating logical and meaningful definitions as well as marking entries for inflexion and capitalisation (inflexion is a major issue in terms of practical operation of the base, however it is specific to the particular CAT tool chosen for the course; in fact other computer-assisted translation applications available on the market, such as SDL Trados Studio, utilise different solutions for handling word morphology and do not always require marking off words stems). The course also covers setting up text corpora and exporting translation memories, which may later be used for the purpose of term extraction in line with the principles of representation of terminological lexicons.

In short, what we are mostly emphasising is:

- the ability to set up various types of term bases from the perspective of their function and use,
- the procedure of creating new term base entries on various levels of description,
- selecting lexical items to be fed into the term base from the perspective of unit length, frequency, representativeness for the given lexicon and grammatical category,
- maintaining the term base in good working order by appropriately marking inflexion and capitalisation as well as removing duplicate terms and synonyms.

The following figures 4 and 5 present snapshots of parts of the course dedicated to some of the skills referred to above:



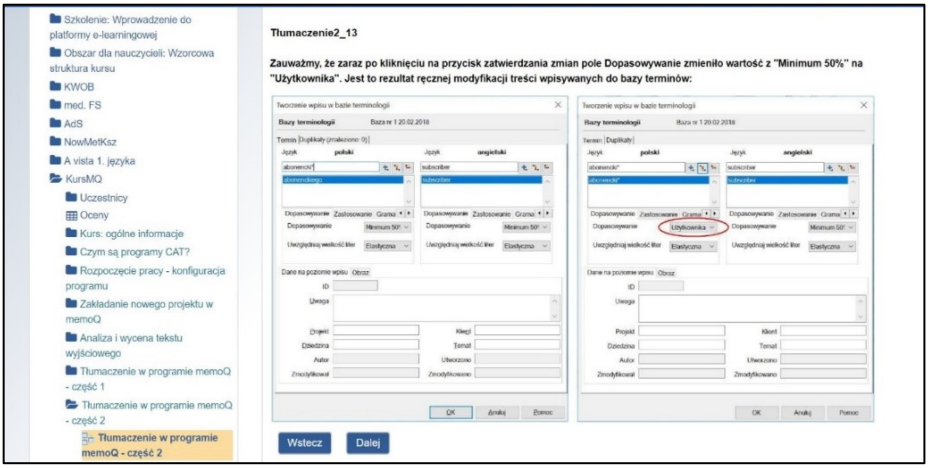
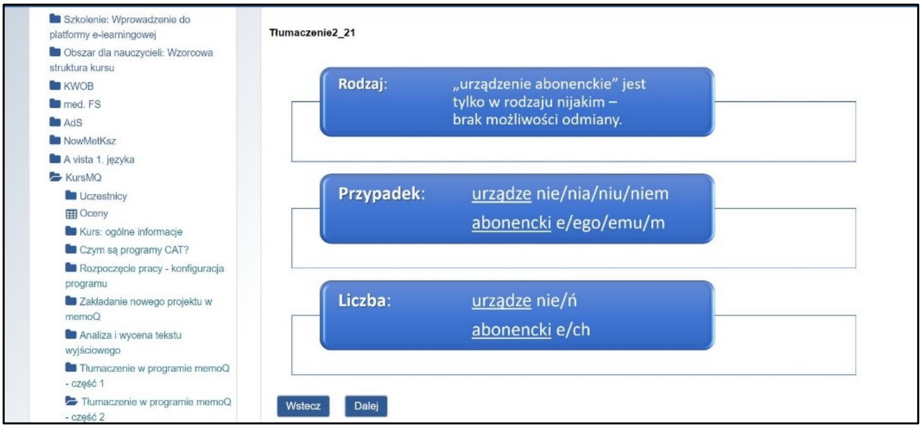


Figure 4. Sample course pages dedicated to adding terms to the base – direct method (above) and properly recording inflexion and capitalisation of terms (below).

Source: https://kampus.umcs.pl (Accessed 20.07.2019)



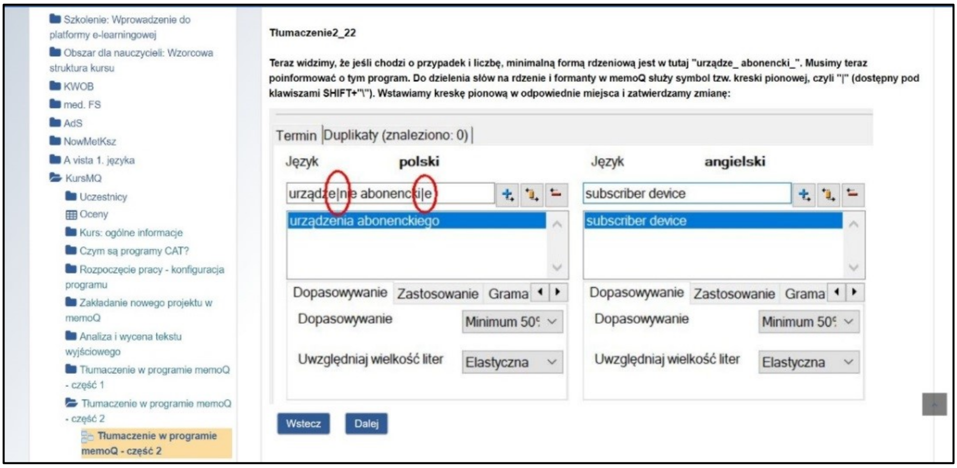


Figure 5. Sample course pages dedicated to the strategy in the area of adjusting term length (above) and the proper placement of inflection markers (below).

Source: https://kampus.umcs.pl (Accessed 20.07.2019)

Having completed our course, students are not only capable of using the software from a technical perspective, but (unlike in the case of the majority of commercially available CAT tool training courses) are also aware of the key linguistic and terminological determinants of translation activity. That is particularly important given the fact that the development of CAT software and its predominance on the translation market appear to be, to a large extent, driven by translation agencies' profit margins which greatly benefit from any tool that streamlines and accelerates the translation process (Szwed 2017, 238). However, it is easy to imagine that in this state of affairs the didactic value of CAT training from the perspective of problems such as equivalence, the treatment of errors, selection of appropriate translation strategies and, notably, handling terminology, may be treated as secondary, or even entirely obsolete.

What is more, the e-learning course referred to above falls in line with the scheme of practical training at the Marie Skłodowska Curie University in Lublin which provides that all translation students must complete internships or work placements as part of their study curriculum. As part of the practical training, the students must perform an appropriate number of tasks for which they receive scores.

These include:

- translating texts,
- editing and proofreading finished translations,
- interpreting (consecutive, escort, simultaneous, liaison),

– performing audio-visual translation (including film subtitles and computer game localisation).

but also:

– compiling text corpora for the purpose of project work and extracting translation memories from these corpora,

– extracting terms to glossaries for the purpose of later import to CAT tools.

Furthermore, the role of terminology manager has been established and assigned to each translation project along traditional functions such as project manager, translator or editor. The terminology manager actively participates in the project work and is responsible for setting up term bases and looking after their appropriate division and classification, feeding basic terminology into the data bases prior to the launch of the project, verifying the quality and condition of data bases after the completion of the project and instructing other participants as to the proper procedure for adding new terms to the bases.

CONCLUSION

By doing the above, the University makes sure that students are not only aware of the importance of modern computer tools in use on the translation market and capable of using some of the most popular among them, but also possess the necessary translation competences including, notably, skills in the area of terminological activity. The use of e-learning infrastructure offers numerous benefits, the most significant of which include, for our purposes, the possibility to understand the value and importance of terminological activity through its application in practice, which is possible owing to the individualised nature of the self-study scheme. With the appropriate structure and built-in guidance, students become accustomed with the fundamental techniques and principles of terminological work in an up-to-date context and modern technological environment and, subsequently, learn to apply that knowledge in their own translation projects. Thus generated expertise is easily transferable to other forms and stages of translation training in the university and also to subsequent, hands-on professional activity. Notably, this type of synthesis between academic knowledge and modern computer skills is otherwise difficult to obtain due to curricular constraints and, perhaps, the novelty of the idea of including terminological activity in translator training schemes. It does, however, seem to be an important and valuable programme component, especially in light of the growing importance of terminology work as outlined in the earlier parts of this paper.

It is beyond doubt that this scheme will be subject to future improvement and development along with the appearance of, among others, new computer programs and new e-learning infrastructure. As mentioned earlier, Moodle is certainly not the most modern e-learning platform and may in the future become outdated or even entirely obsolete. The same holds true for CAT tools which are rapidly gaining popularity worldwide and becoming ever more complex and sophisticated. At the moment translators have a wide array of applications to choose from with different user interfaces, core functionalities and underlying algorithms. While the treatment of specialised terms and the principles of terminological activity are independent from such technical considerations, it seems important to discuss ways in which these differences will influence the nature and quality of terminology work (an example being the inflexion markers in memoQ as discussed in part 3 of this paper). Another crucial consideration appears to be the legal status of terminology data bases which is subject to both local and EU legal regulations and as such renders itself rather unclear. The issue of data base protection, and the particular laws under which such protection is to be guaranteed, requires attention as it may have an impact on the handling of term bases in the future.

In light of the above it becomes clear that any person responsible for practical training in higher education institutions must exercise a good deal of diligence and always be aware of the new developments on the market, in particular due to the fact that the very goal of practical training is to prepare students to function on that market with all its new features, expectations and requirements. It seems that the efforts undertaken at the Maria Skłodowska Curie University are a good example of this approach.

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APPLYING THE CEFR DESCRIPTORS FOR ONLINE INTERACTION AND MEDIATION FOR THE DESIGN OF MOODLE BASED TEFL MATERIALS

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Abstract: *In 2017 the Council of Europe, Education Department published CEFR- Companion Volume with New Descriptors. The publication concluded a long process of calibrating, validating and designing descriptors, including the new set for mediation and online interaction. The consultations phase took place (2015-2016) in various educational institutions, including the SWPS University of Social Sciences and Humanities, where the author supervised the workshops. The article presents the case study which participates in the CEFR implementation programme. The author addresses the questions as to the role of "new" descriptors in the process of designing online materials for TEFL, the criteria for evaluating the new 21st century skills, and the shift to the interdisciplinary perspective of effective (online) communication.*

Keywords: CEFR, online interaction, mediation, Moodle, authorial materials, TEFL

INTRODUCTION

Year 2013 marks the beginning of the four-year-process of calibrating, validating and designing descriptors, including the new set for mediation and online interaction, run by the Council of Europe and managed by Brian North from Eurocentres. The consultations phase (incl. the qualitative and quantitative validation) took place (2015-2016) in various educational institutions, including the SWPS University of Social Sciences and Humanities in Warsaw, Poland.

As part of the consultation phase carried out in the institution, the author supervised the workshops participated by 14 distinguished academic experts and professionals who specialize in language education.

The original CEFR descriptors were published in 2001, and the document did not include the set of descriptors on mediation.

> The *Common European Framework of Reference for Languages: Learning, teaching, assessment* (CEFR) was published in 2001 (European Year of Languages) after a comprehensive process of drafting, piloting and consultation undertaken by the Council of Europe in Strasbourg. Available in 40 languages, the CEFR is one of the best known and most used Council of Europe policy instruments and has been the subject of Recommendations by its Committee of Ministers and Parliamentary Assembly. The CEFR has also been adopted by the European Commission, including in their EUROPASS project and the project to establish a European Indicator of Language Competence. (Bergan and Qiriari qtd in 2017: Council of Europe, "Foreword")

Finally, in 2017 the Council of Europe, Education Department published *COMMON EUROPEAN FRAMEWORK OF REFERENCE FOR LANGUAGES: Learning, Teaching, Assessment* - *Companion Volume with New Descriptors.*

The problem worth addressing is the role the CEFR descriptors as specified in *the Companion Volume* play in designing authorial and online materials for TEFL, in evaluating the new 21st century skills, and in providing a shift to the interdisciplinary perspective of effective communication. However, first it is essential to find out how the CEFR descriptors can be used to profile a 21st century learner in the integrated skills framework with a particular focus on his/her mediation and online interaction skills. Finally, the provided research sample presents a practical experiment that involves the role of "new" descriptors in the process of designing authorial online materials for Teaching English as a Foreign Language. The main purpose of the experiment was to put the "new" descriptors into practice, to motivate teacher trainees with the "learning by doing" approach, to make them aware of the theoretical and practical aspects of mediation and online interaction in TEFL and, finally, to gain feedback on the application of the "new" descriptors in learning, teaching and assessment also from the perspective of the 21st current learner and future teacher.

1. USING THE CEFR DESCRIPTORS TO PROFILE A LEARNER

The CEFR provides the tools for learning, teaching and assessment (North: "In that order." (2018: min. 3:19) in the form of illustrative descriptors that profile a foreign language user in terms of his/her overall language proficiency: aspects of competence (Communicative Language Competencies i.e. linguistic, sociolinguistic and pragmatic) as well as communicative activities (reception, production, interaction and mediation) (North 2018).

The levels now range from Pre A1 (with A1 beginner) to C2 (near native speaker) with the trend towards: more "Integrated skills approach" and authentic language use (North).

The role of the language user has been also redefined with a shift from a learner (or speaker) "mobilizing linguistic resources" from the 1960s to 1980s, to a 21st century social agent (involved in negotiation of meaning and co- construction of meaning "mobilizing general and linguistic competences", including pluricultural and plurilingual competences, by using "purposeful, collaborative tasks whose primary focus is not the language" (North, 2018: min. 15:38- 20:14). North (2018) also claims that treating learners as social agents includes "involving them in the learning process, recognizing the social nature of language learning and use" (2018: min. 18:12). Therefore, the tasks should involve: the integrated skills approach, collaboration, processing and mediating the text (North, 2018: min. 21:15).

2. APPLYING THE NEW DESCRIPTORS FOR MEDIATION AND ONLINE INTERACTION

2.1 General principles

As mentioned before the original set of CEFR descriptors did not include the descriptors for mediation as well as for online interaction, reactions to creative text (including literature), plurilingual and pluricultural competence. Moreover, the old scales have been updated (for example, the old phonological scale has been replaced and pre-A1 level defined - to name only a few changes).

For Polish native speakers, the term "to mediate" means facilitating/enabling the communication between two opposing parties, often managing the tension. The concept of "mediation" as defined in the new CEFR Companion Volume involves not only mediating communication but also ideas/concepts and texts. The new descriptors define all three types of mediation. By "mediating communication," the Companion Volume's authors mean not only disputes but also "facilitating pluricultural space." (North, 2018: min. 26:13)

> In both receptive and productive modes, the written and/or oral activities of mediation make communication possible between persons who are unable, for whatever reason, to communicate with each other directly. Translation or interpretation, a paraphrase, summary or record, provides for a third party a (re)formulation of a source text to which this third party does not have a direct access. Mediation

> language activities, (re)processing existing text, occupy an important place in the normal linguistic functioning of our societies. (North, 2014)

All types of mediation-based activities should, therefore, include "collaborative interaction with the peers" (North). For successful mediation, then, specific strategies must be applied (for example: adapting the text to the user's needs). The CEFR authors had to update the framework by including "other scales related to mediation," such as: online conversation and discussion, goal-oriented online transactions and collaboration, plus: plurilingual and pluricultural competences (North).

2.2 Case study - a practical experiment

At present, two years after the publication of the volume, the SWPS University participates in the case study proposal/project whose main aim is to implement the new CEFR descriptors. The Council of Europe encouraged the participants to design their own cases that would aim at the implementation of the new CEFR descriptors and submit them for their evaluation. Twenty two students of the class Methods and Techniques of Teaching English as a Foreign Language (3rd year B.A. studies, English Philology groups, i.e. FL teacher trainees) designed (February 2019 - May 2019) their own modules on the SWPS University (Moodle) e-learning platform. The objectives of the course included preparing, uploading and managing the authorial materials for teaching/ learning EFL with a particular focus on using different categories of mediation and online interaction.

The students were divided into two groups and given access to the Moodle platform with the temporary status of Teachers. They had had a five-semester experience as users of the Moodle platform, i.e. students, in the variety of online courses offered by SWPS University (some in the blended mode and some meant for self-study). Moreover, they had spent the previous semester as Teachers designing online materials as part of the 1st semester course requirements. Therefore, it could be assumed that these digital natives with distinctive experience in designing and using online materials and knowledge of the methodology of TEFL, CALL, etc. were well prepared and eager to engage in the planned activities. Their task was to invent the topic for their ca. 60-minute module and the appropriate online activities. Teacher trainees were asked to design their own modules using appropriate (mostly B1/B1+, B2/B2+, C1) CEFR descriptors for the Communicative Language Competences, Mediation and Online Interaction i.e. "building skills for "online conversation and discussion, goal-oriented online transactions and collaboration" (North, 2017). Follow up activities included class and online discussion on the design and implementation of the CEFR descriptors on the Moodle platform, class micro-teaching sessions, course and self-evaluation.

The post-project reflections have made the author question the original idea of providing students with the theory on mediation and the new descriptors first and then giving them the total freedom of designing their own module content. It proved a challenging task as many claimed (in the post-project student self-evaluation comments) that the tasks seemed very difficult first. It took more time than expected to explain the very abstract idea of mediation. It seems that giving concrete examples of mediation-based activities, selecting and distributing concrete descriptors and assigning them to individual students would have been much less time consuming and more effective particularly for the weaker students. On the other hand, however, the used approach–boosted creativity and motivation.

The primary aim of the project was to address the questions as to the role of "new" descriptors in the process of designing online materials for Teaching English as a Foreign Language, to motivate teacher trainees, to shift to the interdisciplinary perspective of effective (online) communication. The students chose a variety of topics, ranging from lifestyle, travel to psychology, media, British and American culture and literature. Some students (mainly foreigners) chose topics requiring the focus on cross cultural issues, e.g. one of the Chinese students prepared a very interesting set of activities to mediate a short literary text from Chinese to English. In the mentioned module, the student trainee focused on the descriptors for such aspects as: text processing, translating the written text, responding to the literary text. Asked to discuss the chosen image first (on the online forum), students engage the strategies for mediating concepts, and collaborate to construct the meaning of some ideas. This activity can be also adapted for the class usage (traditional classroom teaching mode). "Collaborating to construct a meaning is concerned with stimulating and developing ideas as a member of a group. It is particularly relevant to collaborative work in problem-solving, brainstorming, concept development and project work" (North & Piccardo, 2016: p. 29).

3. THE NEW DESCRIPTORS FOR ONLINE COMMUNICATION AND INTERACTION IN PRACTICE

As it can be seen, student tasks in the project concerned a variety of descriptors (for mediation: text summarizing, note taking while listening, mediating concepts), with a particular focus on:

ONLINE CONVERSATION AND DISCUSSION

- Can engage in online exchanges, linking his/her contributions to previous ones in the thread, understanding cultural implications and reacting appropriately. (C1)
- Can participate actively in an online discussion, stating and responding to opinions on topics of interest at some length,

> provided contributors avoid unusual or complex language and allow time for responses (B2) (2017: Council of Europe p. 97)

According to the 2017 CEFR framework, the scale has been designed to reflect the nature of the online interaction, which is different from face-to-face interaction in many aspects (more redundancy, confirmation of correct understanding, reformulation to facilitate comprehension, management of emotions (Council of Europe, 2017: p. 96).

> Online conversation and discussion focuses on conversation and discussion online as a multi-modal phenomenon, with an emphasis on how interlocutors communicate online to handle both serious issues and social exchanges in an open-ended way. (Council of Europe, 2017: p. 96)

The detailed explanation and the corresponding descriptors for a particular level can be found in the 2017 CEFR document (pages 96-98). As far as the progression from Pre-A1 to C2 is concerned,

> … the move towards higher levels expands from basic transactions and information exchange at the A levels towards more sophisticated collaborative project work that is goal-oriented. This can be seen as a progression from filling in predictable online forms at Pre-A1, to solving various problems in order for the transaction to take place at the B levels, through to being able to participate in, and ultimately coordinate, group project work online at the C levels.” (2017: Council of Europe, p. 98)

The document also specifies “Goal-oriented online transactions and collaboration,” with such skills mentioned as: “Can engage in online collaborative or transactional exchanges that require simple clarification or explanation of relevant details, such as registering for a course, tour, event or applying for membership” (B1) or more advanced “ Can deal effectively with communication problems and cultural issues that arise in an online collaborative or transactional exchange by reformulating, clarifying and exemplifying through media (visual, audio, graphic) (C1) (Council of Europe, 2017: p. 97).

In the presented case, students learnt the concept of mediation and online interaction by experiencing the process of designing particular activities with appropriate instruction, level, etc. adapted to the needs analysis. Moreover, students, by being the member of the community of practice, learnt through doing things and exchanging feedback with their peers (both online and offline, in the computer lab and outside the school premises). The chosen topics were especially useful for the CALL rather than traditional classroom. In fact, some of the above activities were adapted and delivered later with the use of the Interactive Whiteboard. (Figure 1)

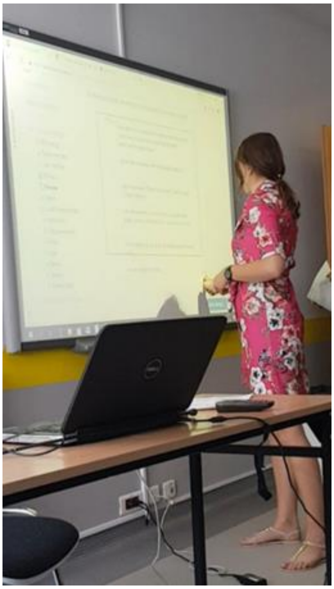

Figure 1. Adapting Moodle based activities to the IWB usage in the classroom (the Author/Teacher trainee performing micro/peer-teaching activities).
Source: Author's own materials, 2019

For example, one of the course participants commented in the self-evaluation section that "The descriptors for mediation proved to be very useful in order to design new activities. Mediation descriptors boosted my own creativity in designing activities and helped students communicate with each other" (Rybak, 2019). In fact, this opinion was shared by other participants. She also acknowledged some areas of future improvement (the students were asked to refer to the EPOSTL document), such as: time management and learner autonomy.

CONCLUSION

Applying the new CEFR descriptors in the CALL context, i.e. the Moodle platform and the IWB, boosted student/teacher creativity, helped to understand how descriptors reflect the complex nature of the concept of mediation and the corresponding strategies. Moreover, it forced one of the aims mentioned by North (2018) i.e. "purposeful, collaborative tasks whose primary focus is not the language." (min. 20:54) Students and the teacher built a community of practice, which was based on collaboration, exchange of information, application of instant peer feedback, peer support and teacher mentoring. In effect, student-teachers in the course designed digital materials aimed at FL practice but which were structured on the basis of the topics of their own interest, often connected with their hobbies and outside school activities. In fact, many group members were foreigners (Spanish, Ukrainian, Turkish, Chinese) who incorporated the elements of their own culture into the FL teaching context. It resulted in shaping the intercultural competence of the group members.

> Authentic materials stimulate, facilitate and entertain. In addition, the approach based on the provided food for thought (reading materials, discussion questions, video materials) guarantees that the students have something to write about and are forced to use appropriate vocabulary and formulate their own opinions. (Gadomska & Krajka, 2017: pp. 188-189)

Therefore, this approach promotes effective communication. The "learning by doing" oriented experiment proved successful as students (authors of their own online materials) have understood the nature of online communication in the foreign language, action oriented learning, the need to employ the connections between the real world and the tasks, to recognize priorities (North) and above all, the need to adapt to the 21st century technological challenges and "the increasing linguistic and cultural diversity of our societies" (Bergan and Qiriari qtd in 2017: Council of Europe, "Foreword"). The author intends to continue the evaluation of the research method and its role in the application of the CEFR descriptors in the further stages of the study. The presented case study is part of a larger project designed in accordance with the CEFR implementation programme requirements (run under the supervision of the Council of Europe experts).

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DEVELOPMENT OF GEOMETRICAL THINKING VIA EDUCATIONAL SOFTWARE BY PUPILS OF ELEMENTARY SCHOOL

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Abstract: *The study is aimed to describe the using of geometrical educational software oriented to develop geometrical spatial thinking. This software is available on the webpage www.delmat.info. We would like to show his functions, propose concrete thematic areas in Slovak and Polish curriculum in the elementary level useful for this software. Future research in Polish elementary school in the 1-3 grades will be discussed.*

Keywords: Polish and Slovak math curriculum in elementary level, geometrical and spatial thinking, educational experiment during the mathematical lesson.

INTRODUCTION

According to Karolčík, Čipková, Veselský, Hrubišková (2013) educational applets belong to the smallest program units, which can be launched separately or as plugins of web pages. Their didactic usage is limited mainly to the mathematical calculations in more complex tasks, addition of missing data, explanation of problems or simulation of phenomena or processes. The interactive presentation mainly consists of animations supplemented with graphical and sound effects. Their progress can be influenced, e.g. by the change of the input quantities.

The mentioned study shows that prepared educational applets can be evaluated by three groups of respondents: information technology (IT) specialists, users - pupils or students and teachers.

IT specialists observe mostly, if the applets:

- are clear, simply and user-friendly;
- have good graphical processing and design variety;
- give the possibility of accessing the software through the internet;
- support clarity with illustrative examples, animations, pictures;
- have good interactivity.

Teachers also believe that the applets must be clear, interactive, simply and user-friendly and also, they must have good graphical processing and design variety. It is important for them that the applets:

- have completeness of content with multimedia elements;
- have comprehensibility and language mutation in mother tongue;
- Users-pupils and students has specific expectations, that the applets are;
- proficiency prepared and they bring perfection of data and information;
- suitable for students and pupils considering their age.

It is important in our case that geometry applets respect the abilities of pupils at elementary schools. We use these applets as a supporting tool for pupils' development of spatial thinking.

In Poland, the evaluation of teaching games is used mainly for formative evaluation (allowing to shape the scope of work on the didactic game) it is carried out before and during program development in order to optimize it.

It involves collecting and analyzing data. A distinction is made between two types of formative evaluation: process evaluation, which aims to evaluate the educational process, and performance (product) evaluation, which aims to evaluate the outcome of the educational process e.g., changing the level of spatial thinking of young students relative to the evaluation of other students who did not use computer program (Griffin, Butler, 2005).

Program or computer game evaluation includes two assessments: process evaluation and product evaluation. The first contains:

- interviews, surveys for teachers, parents or students, used e.g. to find out the attractiveness and level of acceptance of the program;
- observations regarding the educational process. They are especially popular at the initial stages of developing an information program;

- behaviour analysis can be applied using modular programs and in which a variety of teaching methods are used, not only computer-based.

Product rating includes:

- tests checking the knowledge of the subject;
- observations of behaviour in control and experimental groups. (Margulis, 2005).

The main goal of product evaluation is to determine which factors in the educational process determine the possible effects of the program. Detailed information obtained as a result of product evaluation should be the basis for program optimization.

Space thinking has an important role in the development of mathematical and logical thinking and it is also important for development of the competence of solving real-word problems. It is a task for teachers to prepare suitable educational activities for pupils in the frame of development of their space thinking. According to Sinclair, Bruce (2015) some new trends in geometry education at primary level are:

- the role of spatial reasoning and its connection to school mathematics in general and school geometry in particular;
- the function of drawing in the construction of geometric meaning;
- the affordances of digital technologies in geometric and spatial reasoning;
- the importance of transformational geometry in the curriculum (including symmetry as well as the isometries);
- extending primary school geometry from its typical passive emphasis on vocabulary (naming and sorting shapes by properties) to a more active meaning-making orientation to geometry (including composing/decomposing, classifying, mapping and orienting, comparing and mentally manipulating two- and three-dimensional figures).

According to Wai, Lubinski, Benbow (2009) space thinking in education supports STEM (science, technology, engineering and math) disciplines. They mean, that spatial ability has emerged as a salient psychological characteristic among pupils who go on to develop expertise in STEM domains.

Many pupils have problems with using spatial imagination in the solving of concrete tasks and they have a problem, for example, with building the solid, if they know the top, front and right view. We developed applets as a supporting educational tool, which help and supplement pupils’ manipulative activities with solids.

1. THE ROLE OF GEOMETRICAL THINKING IN PRIMARY MATHEMATICS EDUCATION

Solving many real life problems involves geometrical thinking, which is based on visual concepts of geometric notions. We have carried out some research on pupils' understanding of geometric notions at primary level (Gunčaga, Žilková, 2019). This study shows, that many pupils have a problem with connecting the name of the plane geometric shapes with the properties of the shape. Another problem is to identify the geometric shape on the basis of given models (Gunčaga, Tkačik, Žilková, 2017). These problems are connected with the teacher training at universities. Many pre-service teachers can identify planar shapes only in standard position and they do not have an accurate understanding of the properties of the shapes or they are uncertain in terminology (see Žilková, Gunčaga, Kopáčová, 2015).

According to Hejný et al. (2006) the ability to manipulate with three-dimensional (3D) objects is built gradually. The starting point is pupils' direct tactile and visual experience with models of the mentioned objects. The gradual shift to mental operations goes through many stages in which each new one lacks a certain type of perception with regard to the previous one.

Jirotková (2010) states that these activities are focused on the idea that the pupil

- obtain enough experiences about object,
- know the object during the activity with it,
- can discuss about object with other pupils in his class or group,
- tries to define with own words the properties of the object,
- can change with the teacher's help his own definition of the object up to the correct definition.

Solids or 3D objects belong to an important part of geometric notions in primary education. According to Weigand (2009) the teaching of geometric notion has three important aspects: the building of reasonable imagination, acquisition of knowledge and acquiring skills.

If we built reasonable imagination about a geometric notion, then we perform with pupils some manipulative activities with concrete objects, perception at pictures and models, verbalization of geometric objects. Acquisition of knowledge is based on knowledge of the properties of geometric notions, relationships between mentioned properties and relationships between discovered a new geometric notion to the other already known notions. Acquiring skills by pupils is realized via the ability to work and manipulate with geometric objects, making simple constructions or calculations and also solving problems.

The development of information and communication technologies (ICT) brings possibility of supporting this process of pupils' understanding of geometric notions and spatial imaginations via the development of special educational geometric applets. We would like to present in our article some possible educational interventions in geometry education with the help of the mentioned applets.

2. SPATIAL THINKING ACCORDING TO THE NATIONAL CURRICULUM IN MATHEMATICS ON THE PRIMARY LEVEL IN SLOVAKIA AND POLAND

The Innovated Slovak State Educational Program Mathematics – Primary Education (ISEP(2014)) obtains in the first year in the thematic area “Geometry and measurement” the notion of spatial geometric figures: cube, cylinder, sphere. It is expected that the pupil can name the space geometric figures. He should be also able to draw and put these figures according to the teacher’s instructions, to identify the place of geometric figures in the space.

The thematic area “Geometry and measurement” includes in the second year the topic ”Creating a building from cubes“. This topic assumes that pupils can build a simple building from cubes according to a template or a figure.

The solid cube is explained in the third year – vertexes, edges, faces. For this reason, it is expected, that children can build buildings from cubes according to a given plan – the top, right and front view. These plans obtain a marked number of stacked cubes. Children can identify rows, columns by building from cubes and also, they can create a plan – the top, right and front view with a marked number of stacked cubes according to a concrete building from cubes.

There is an extension in the fourth year – to create different buildings from cubes according to a plan – the top, right and front view, to create and verbally describe your own building from cubes and to draw a plan – the top, right and front view from a concrete building from cubes.

There exist differences between countries in the State Educational Curriculum, which will be described in the following part of the Polish Curriculum for development of spatial thinking on the primary level. The child begins his development of spatial thinking from mastering the orientation in the body schema and the direction-spatial orientation towards the immediate environment (Black, Walker, Fernald 2017).

There are the following spatial thinking requirements in primary education that fall within the scope of mathematical education: achievements in the field of understanding spatial relations and size characteristics.

The problem with spatial thinking in Polish education begins to appear in the mathematics lesson in the geometry classroom, it quickly becomes apparent which student has trouble understanding the topics, spatial vision. It turns out that this is a large group of 30% (Makarewicz, 1999). Problems start by lower elementary school pupils when they draw parallel and perpendicular lines. Pupils do not know how to operate a ruler and a set square, the arrangement of these two instruments arouses their emotions, they are often discouraged. Some pupils are very clever, but there is a group of pupils who, despite having geometric accessories, draw crookedly, do not see right angles, and have difficulties drawing precisely. It is difficult for them to see geometric dependencies, they do not understand the instructions in the textbook, and they are unable to plan the next stages of creating drawings or solving a geometric task (Makarewicz 1999).

In recent studies, Kopczyński, Gałuszka (2019) show on the example of two experimental and control groups how to increase the level of spatial thinking. For this purpose, the researchers used an educational mat that allows manipulation of objects on the matrix. Groups of pupils in primary education were tested for: solving mathematical problems, performing simple equations and geometric tasks that require advanced spatial thinking.

In the area of geometry skills, the control group achieved scores in a range of 0–6 points in the initial measurement (test K3 M1), averaging 2.20 points (SD = 1.65), usually 1 point. In the final measurement, the control group scored 0–6 points, averaging 2.74 points (SD = 1.88), usually 2 points.

In the area of geometry skills, in the initial measurement (test K3 M1), the experimental group achieved scores in the range of 0–6 points, averaging 2.46 points (SD = 1.67) out of 6 points possible, usually 2 points. In the final measurement, the group scored 0–6 points, averaging 3.55 points (SD = 1.80), usually 3 points (Kopczyński, Gałuszka 2019).

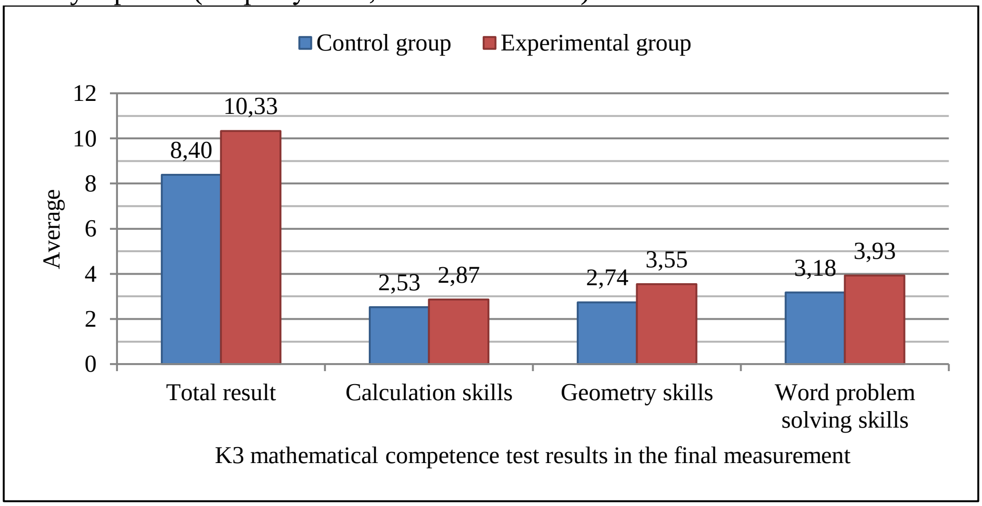

Figure 1. Comparison between the K3 M2 mathematical competence test results of the control and experimental group in the final measurement.
Source: Own work

The presented results show a significant statistical significance of the EduMata didactic aid (cubes and forms) on the results achieved in mathematical thinking among 3rd grade primary school children. There was a significant increase in general mathematical competences and a significant increase in calculation skills, geometry skills and word problem solving skills in the final measurement. Thus, the measurements show that the largest point difference between the groups in the final measurements noticed in the field of geometrical competence. This means that the manipulation of various objects on this stage significantly contributes to the development of spatial thinking.

3. SPATIAL THINKING IN THE CONNECTION WITH NATIONAL CURRICULUM IN COMPUTER SCIENCE ON THE PRIMARY LEVEL IN POLAND

Spatial thinking and spatial orientation in mathematics lessons along with the development of new technologies is directly related to the IT competences and information literacy of students. The development of skills such as creativity, innovation, critical and logical thinking skills of students can be shaped through tools and software that develop students' multifaceted thinking (for example, Delmat Applets). For a better understanding of spatial thinking, it is necessary to be able to use virtual, interactive orientation, and thus to support traditional teaching methods with modern tools. In addition, taking into account the specificity of the digital society in which modern children are brought up, an argument arises to use the natural potential of students to operate computer devices and programs for mathematical education. This way IT competences are transferred from the level of fun or free time activities to the field of school work methodology. "In this way, you could show students the relationship between mathematics and computer science. They could expand their knowledge by playing, learning about computer programs used for mathematical calculations and finally stimulate their own creativity, the ability to think logically and spatial imagination" (Maj, Falkiewicz 2018).

Using of Information and Communication Technologies (ICT) can help in the use of different kinds of models in mathematics education. These models can help to develop pupils' spatial thinking. For this reason, great importance in education has been attached to the use of computer applications, online resources and communication by covering all pupils with ICT education. Today's expectations of citizens' digital competences go beyond traditional computer literacy and technological proficiency. These skills are still needed; however, they are no longer sufficient at a time when computing is becoming a common language in almost every field, each of which is constantly being equipped with new tools. "Computational thinking that teachers develop among their students is a gain for students, and examples of programs that they propose to do will also have a triple benefit for students. They will strengthen the learning of content from the subject, students will create things important for themselves, the teacher will easily introduce to his arsenal of teaching resources and tools afforded by modern technologies. It will be true learning through creation, and yet it is the highest strategy for acquiring knowledge and skills (Rostkowska 2017).

Applets support the work of teachers and pupils with the interactive whiteboard. It is important, that the pupil can use notions top, right and front view. They have also propaedeutic function. Applets develop not only spatial imagination, but also informatics competences. If we draw spatial geometrical figures through planar figure on paper, then it is important that this figure evoke some spatial geometric figure.

The methods and techniques learnt in ICT classes should give pupils the skills of logical and algorithmic thinking, programming, using computer applications, searching and using information from various sources, using computers and basic digital devices as well as applying these skills for various purposes, such as making calculations, processing information and its presentation in various forms (including visual, see Rozporządzenie [Regulation], 2017a and b). Therefore, it can be concluded that the elements are necessary for computational thinking which is understood as "thinking that accompanies the processes of solving problems by means of computers, and which is characterized by the following features:

- The problem is formulated in a form that makes it possible to use a computer or other devices to solve it;
- The problem consists in the logical organization of data and its analysis, which can be facilitated by, among others, data models and model simulations;
- The solution to the problem can be obtained by using an algorithmic approach and therefore takes the form of a series of steps;
- The design, analysis and computer implementation of possible solutions leads to the most effective solution and to utilization of a computer’s capabilities and resources;
- The experience gained in solving one problem can be used to solve other problem situations." (Sysło 2019)

4. DESCRIPTION OF VIRTUAL MANIPULATIVES WITH CUBES

One of the aims of the project APVV-15-0378 and the project KEGA 003TTU-4/2018 is to create learning environments for pupils of primary education such that they support their spatial imagination and orientation in the space. At the same time, all suggested educational environments and interventions should be projected so that they reflect abilities, interests and needs of children in young-school age. From this reason we created so called “mirror activities” with buildings from cubes. Under the term “mirror activities” we understand activities with the same contentual mathematical basis but realized in other educational environments. In this part of the paper we present justification for the design and description of educational mobile applications which provide interactive environment for creation of buildings from cubes, their record or interpretation, respectively. In doing so we assume that pupils will realize the same tasks using real cubes, grid paper and pencil at first. Interactive applets should create alternative educational environment; an environment for exploration, creation and verification of hypotheses, respectively. The task of educational applets is to help pupils in the transformation of spatial and planar representations of buildings from cubes.

In the process of creation of educational applets focused on virtual manipulation with cubes we came from the paradigm of research method Design Based Research (DBR). DBR assumes cyclical repetition of educational interventions, their evaluation and adjustment of intervention according to observed research findings from pedagogical praxis. The result of multiple repetition of development of applets is 5 educational interactive products designed for pupils of primary education:

Applet No 1. The goal of the applet available at http://www.delmat.info/a/8b/ is to develop an ability of pupils to **create a building from cubes according to the plan.**

Applet No 2. The goal of the applet available at http://www.delmat.info/a/8d/ is to develop an ability to **create a plan according to a building from cubes.**

Applet No 3. The goal of the applet available at http://www.delmat.info/a/8c/ is to develop an ability to **create three views (top, front and right view) of a building from cubes.**

Applet No 4. The goal of the applet available at http://www.delmat.info/a/8a/ is to develop an ability to **create a building from cubes according to three views.**

Applet No 5. The goal of the applet available at http://www.delmat.info/a/8e/ is to develop an ability of critical thinking and so to f**ind a mistake in a building from cubes and correct it** so that it corresponds to the three views.

Applets No. 1 to No. 5 are ordered according to the level of complexity for pupils. Research within the DBR methodology showed that creating a building from cubes according to the plan is for pupils an easier task than to create the plan of a building. Similarly, working with three views is more difficult in terms of spatial imagination than working with a plan. Pupils considered the task about finding and correcting mistake (applet No. 5) the most difficult. Therefore, we recommended to include this task to the highest grades of primary education and going beyond to the low secondary education.

Applets provide so called "inverse tasks" which means that a pupil should be able to create a building (create a real or virtual model) according to a planar representation (plan or three views) but also an inverse task – to create a planar representation of a building from cubes on the basis of a virtual interactive model of a building from cubes. Applets No. 1 and No. 2 generate inverse tasks with a focus on the ability to understand and know how to interpret a plan of the building (Figure 2, Figure 3). A plan of a building is a unique representation of model of building, therefore, there was not any problem with the implementation of the applet from the point of view of the evaluation of correctness of the solution.

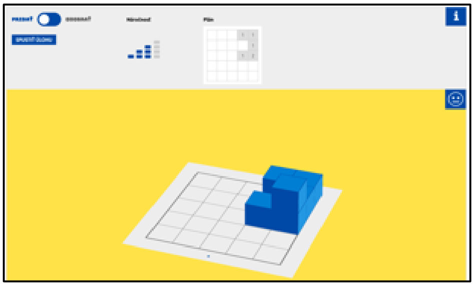

Figure 2. Construct a building from the plan

Source: Own work

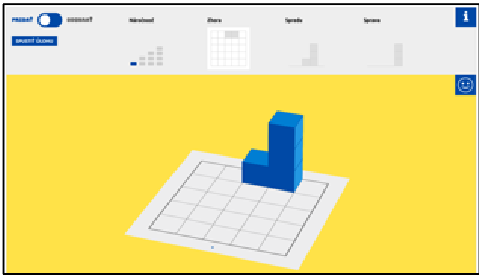

Figure 3. Create a base plan of the building

Source: Own work

Applets No. 3 and No. 4 generate inverse tasks with a focus on development of ability to understand three views (Figure 4, Figure 5) and to be able to apply them. Three view do not have to be a unique record of a building from cubes. Hence, the evaluation of correctness of the solution in applet No. 4 was more difficult to implement to the software. We resolved this problem in the way that no correct solution of a pupil was evaluated as correct even when a task could have multiple correct solutions. This property enables the teacher to create good research educational environment for discussion about the number and diversity of solutions within the activities.

In the applet No. 5 a pupil should check the building from cubes according to the three views, find there a mistake and add or remove some cubes to correct this mistake so that all three views correspond with the building. At this time this applet does not have an inverse alternative.

In the design and implementation of the applets we chose to place the building from cubes and its records to the square grid which should help pupils to better orientate themselves. For this reason ~~is~~ correctness is necessary of the creation of the top view or a plan evaluated also in relation to the location of the building from cubes in a square grid. The front view is on the workspace labelled with a small blue dot so that the pupil's orientation after moving the building was easier.

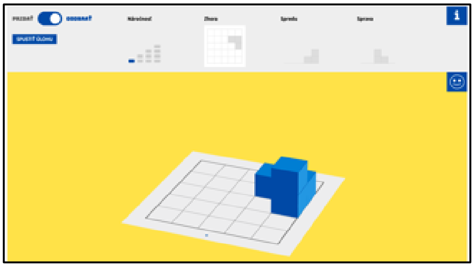

Figure 4. Create a building from three views

Source: Own work

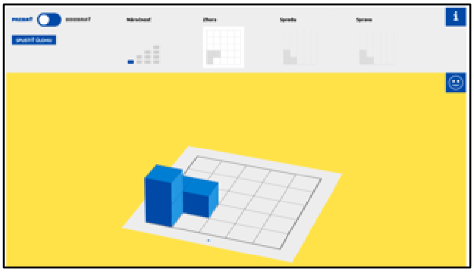

Figure 5. Create the top, front and right view

Source: Own work

From the user's point of view we chose the same design for all types of applets so that the environment of buildings from cubes was known to pupils. On the main workspace (yellow colour) one works with a model of building from cubes, on the help workspace (grey colour) one can change parameters of the task or see plans and three views. Applets enable to add and remove cubes or squares according to the type of task. Adding a cube to the building or a square to the plan is realized only by clicking on the position where the pupil wants to place the object. Feedback about the success of solution of the task is secured via emoticons (happy, sad). Furthermore, in case of correct solution a window with confirmation of success appears. Neither correct nor incorrect solutions are counted. This is because the tasks should not frustrate pupils and not provide space for comparison between pupils from the success point of view. The environment should fulfil the function of free observation and exploration without stress or fear from success.

We plan to insert the information about the use of applets or methodical approach how to use applets to the part labelled with "i". This part will be created after further verification and chosen information will be selected according to the requirements of pupils and teachers. Till now we have been testing intuitive handling with applets and on the basis of results the informational-methodology section will be supplemented. We also think about inserting a short instructional video. In the applets we did not use on purpose many words and we tried to choose control elements so that they were intuitive and could be used without the knowledge of Slovak language. In case it turns out that pupils from other countries have problems with a language barrier we will think about the English version of applets.

Despite the fact that applets are responsive and they should adapt to the device where they are used, we recommend the use of applets on tablets, interactive boards or laptops. Smartphones are not appropriate for children of certain age for manipulation with buildings from cubes, they are too small and do not provide space for mutual sharing, problem solving or working in groups.

5. VERIFICATION AND SWOT ANALYSIS OF APPLETS

In the process of design and implementation of applets we realized cyclical pilot verification with pupils in primary education. They were realized by pedagogy students - future primary education teachers. The aim was to get feedback about how pupils adopt to the new environment for buildings from cubes, whether applets meet their needs, abilities and interests and what their reactions are to the applets and their functionality. Research took place individually with each child and the child was observed while working with the applet. The process was recorded on camera where~~as~~ ethic norms of research were complied. From the obtained video-recordings and following transcripts of the videos we extracted codes and categories on the basis of which we made SWOT analysis of applets. From the verification we got information about what children considered to be benefits and disadvantages, what is suitable for them and what is not, what the potential threats are when using applets and so on. We processed results of the video-recordings of 34 children (18 boys, 16 girls) aged 5 to 11 years. The results of the SWOT analysis are described in Tables 2-5.

Strengths of the applets (Table 1) are findings from statements of children and future teachers of primary education about what applets can provide for children from the educational point of view, what benefits they bring, which attributes of applets support interest, needs and abilities of pupils.

Table 1.

Strengths of applets (according to the children and students of pedagogy for primary education)

Strengths
– **Professional and contentual focus of the applet** (development of children's spatial imagination and orientation in the space via buildings from cubes, development of logical and critical thinking, development of mathematical, computer and technical competences)
– **Motivational aspect for a child** (playful and entertaining form, attractive environment, interactivity, natural interest for solving tasks in the applet, learning by playing, children asked for applets to be available at school)

- **Availability and control of applets** (applet is available for free, easy and intuitive handling, understandability of applet, good orientation of the child in the applet's environment, easy manipulation with applet after instructions were given, possibility to rotate building in the applet, good label of the front view – blue dot, easier manipulation with virtual building than with real, applets are appropriate for the interactive board)
- **Methodological aspect of applets** (age appropriate tasks, different levels of complexity of tasks, different types of tasks, possibility to adapt the level of complexity to children's abilities, possibility to correct the solution by adding or removing a cube, understandability of tasks, good orientation using square grid – great help with three views)
- **Feedback** (joy when a smile and message about correct solution appears)

Source: Own research

On the other hand, we observed also weaknesses of applets (Table 2) which means attributes children or future teachers complained about. We also observed that some elements of applets cause negative reactions of children.

Table 2.

Weaknesses of applets (according to the children and students of pedagogy for primary education)

Weaknesses
– **User aspect and control of applet** (instructions needed at the beginning of work with applet, insufficient label of front view – blue dot, impatience when using button add/remove a cube, sometimes children forget about button "start the game" as a start of new game, problem with rotation of model of the building on a smartphone, tablet or 10 inch laptop, size of plan – small numbers in the plan)
– **Instructions for user** (absence of instructions for a child/teacher, methodological instructions for teachers)
– **Feedback** (when a solution is incorrect, the place where is the mistake is not shown)

Source: Own research

Conditions that could help to increase interest about the use of applets were summed up to the category of opportunities (Table 3). Opportunities consist of suggestions for external intervention to the implementation of applet with the aim to improve its professional, methodological or technical aspects.

Table 3.

Opportunities in the use of applets (according to the children and students of pedagogy for primary education)

Opportunities
– **Instructions and methodological instructions** (make and insert a video and audio instructions)
– **User aspect and control of applet** (solve problem with the button add/remove a cube for younger children, some children recommended different colours of cubes, increase the number of cubes that can be placed on each other so it will be possible to build arbitrary building)
– **Feedback as a motivational component** (add also an audio feedback, add points for successful solution, support competitivity and speed)

Source: Own research

When observing children while they were working with applets we identified some attributes that could possibly create threats by usage or could be a possible barrier for use of applets (Table 4). Frequent external threats were caused by choosing an inappropriate level of complexity of applet with regards to needs and abilities of a child or inappropriate methodological process when using the applet.

Table 4.

Threats in the use of applets (according to the children and students of pedagogy for primary education)

Threats
– **Actuality of applets** (development of new software platforms where the applets will not be potentially functional, development of other applets with similar focus)
– **Choice of browsers and devices for functionality of applets** (problem of the browser Internet Explorer, in some browsers the square grid does not show, smartphones are not appropriate although the applets are functional on them, it is necessary to move the screen on some devices so that the whole workplace will be visible)
– **Demotivation and disinterest of children** (panic and disinterest to solve tasks when bad level of complexity was chosen, tiredness, distractions, impatience when an applet is used for longer time, frequent mistakes causing anger, disinterest when inappropriate device with regards to age and motorics of child is chosen)

Source: Own research

The SWOT analysis showed a need to add methodological-informational part to the applet. This part will contain not only information about the usage of applets but also methodological instructions for teachers and video instructions. A discussion about the change in feedback or points for correct/incorrect answers will take place in the future. The result of this discussion will depend on the goal of applets. Verification showed important impact of a teacher on the process of working with applet by the child. Motivation and interest of a child was supported in case when the teacher chose appropriate order and complexity of tasks. On the other hand, if the children's abilities were overestimated or the time of usage of the applet was too long children showed signs of impatience, distraction, anger or aggression. Therefore, we recommend to combine usage of applets with virtual buildings from cubes with constructing real models of buildings, diversify the activities and strictly set the time for work with applets.

CONCLUSION

We presented geometric applets as a supporting tool for understanding of spatial geometric figures and development of spatial imagination by elementary school pupils. It is important according to Žilinskiene, Demirbilek (2015) that educational mathematical applets in education are clear and user friendly. Another important aspect is the possibility of using materials in mother tongue and also the possibility of creating simple outputs. Next important factors were the possibility of accessing the software through the internet and the fact that the educational software has animations, pictures, multimedia elements. We developed our educational geometric applets that fulfilled the mentioned conditions.

Our work with the applets shows that motivation and interest of pupils was supported in case the teacher chose an appropriate way by giving tasks to pupils. On the other hand, if the pupils obtain too difficult tasks or the time of usage of the applet was too long, then they showed signs of impatience, distraction, anger or aggression. Therefore, we recommend to change activities. After usage of applets with virtual buildings from cubes, it is advisable to work with real models of buildings and also change different kinds of activities in an appropriate way.

It is needed the experimental evaluation of effectivity of above described applets for the development of pupils' spatial imagination in elementary school. For this reason, we expect during the next school year the realization of the educational experiment in the elementary school - years 1 to 3 concerned with the development of geometrical thinking through educational web pages (see Partová, Žilková, 2017 a, b, c, d, and e).

The experiment will be conducted in a Polish elementary school in Silesia Province. The research will be carried out using the pedagogical experiment method in two groups. They will include elementary, general, and non-profiled children. The SWOT analysis presented in this article will be used for preparing future research on the use of the presented educational tools for supporting geometrical thinking by pupils on the elementary level (see also Rostkowska, 2017).

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FORMATION OF THE KEY LANGUAGE COMPETENCE OF FUTURE TEACHERS OF UKRAINIAN LANGUAGE AND LITERATURE BY THE USE OF THE DIGITAL TECHNOLOGY OF MICROLEARNING

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Abstract: *The article materials are devoted to the current problem in the system of higher education, namely the presentation of the experimental work for the formation of linguistic competence by using the technology of microlearning in the system of preparing for future teachers of Ukrainian language and literature in studying the course "Fundamentals of speech Culture." The scientific studio presents the experience of microlearning students using the capabilities of social networks Facebook and Instagram, as well as experimental data that capture the dynamics of the development of linguistic competence as the key.*

Keywords: higher education, language competence as a key, microlearning, the course "Fundamentals of Speech Culture", future teachers, digital technologies.

INTRODUCTION

Big changes are happening around people today. We observe how the brain of our children is changing, how they perceive and reproduce information, how they select information, how they communicate with each other and the adult world.

The catalyst of the world transformation at the present stage of society development are the modern information technologies. This conclusion was made in 2017 at the World Economic Forum (World Economic Forum Annual Meeting, 17-20 January 2017, Davos-Klosters, Switzerland). A modern system of education should take into account all of these processes of changing and transformation of the world. And in connection with this, at higher education institutions, we must improve as much as possible the system of education. So what skills should help a person in the world of information technologies and globalization? We believe that this can be quality language and communication skills. In our opinion, all participants of the educational process, teachers and students of different specialties and different programs of education should have the communicative competence at a high level. But this question is more important, definitely, for future teachers. Exactly language teachers take part in very important question − the formation of linguistic personality. One of the criteria of modern language person has literacy as a cross-cutting expertise. We are not talking about the general literacy, which is represented by four activities, namely, speaking, reading, listening and writing. We're talking about the language competence of the future teacher of the Ukrainian language, and it was his literacy level of culture of speech and writing. This level of speech culture of the teacher of Ukrainian language and literature will provide an opportunity for children to learn Ukrainian language norms at a qualitative level. In our study, we focus on the student, who is trained in Ukraine under the "Secondary Education" at the stage of the Bachelor. An approach based on competence, which is determined not only by higher education but also of training throughout their lives ("Council Recommendation on key competences for learning throughout life", 2018), provides clarity and comparability of learning outcomes, acquired competences and skills, and creates a solid foundation for European and global integration. The systematic work of students in the system of the course "Fundamentals of Speech Culture" with elements microlearning technology, as shown by the experimental data, contributes to the dynamics of the development of language competence as a key, and that its presentation directly through the culture of spoken and written word. In this research studio, we have presented a set of measures and surveys element analysis conducted with students who have been trained on the stage of the Bachelor program "Secondary education" during the fifth semester in the system of discipline "Fundamentals of Speech Culture" in the Bohdan Khmelnytsky Cherkasy National University in the Social Communication Institute. The aim of this study is to present the experience in the use of technology microlearning future teachers of Ukrainian language and literature in the system of the course "Fundamentals of Speech Culture" with the use of distance learning elements and modern information technologies, in particular the presentation of the practical component of the training content in the social networks Facebook and Instagram.

1. MICRO-LEARNING IN HIGHER EDUCATION: ESSENCE, CONTENT, PRINCIPLES AND CRITERIA

People began to consume more information content, with small portions. In the formation of the so-called clip thinking can be compensated by shifting the focus from traditional forms to microlearning – when a great course is divided into small pieces, the passage of which takes 5 to 15 minutes. This format is particularly attractive for the Z generation, today's young people in the online space. Social networks have taught them to a combination of visual content and easy game mechanics, and when all this is transferred to the training, information is acquired in better times. In the era of e-learning micr-learning is becoming more popular.

Microlearning – a new educational format that offers to split the process of obtaining knowledge in a short interval training. They can last anywhere from one to five minutes, during which the student receives new information, answers to test questions or repeat the material covered. For example, if we are talking about study language then to replace a 45-minute lessons are coming exhausting traditional short activities that can be suspended and resumed at any time.

As the name implies, microlearning is training in small quantities ("micro"). Micro-learning module has a small size, in focus. In most cases, the duration of three to five minutes with short information portions with concentration on a specific topic or task. Microlearning due to its diversity attracts the attention of the student. This "digital" generation has grown up with the Internet, smartphones and tablets. As a result, they want the training to be concise, accessible, instantaneous, topical and, of course, interesting. Due microlearning students no longer have to sit for the long and boring seminars, lectures or presentations. Now they can find the time to train in busy schedule. The human brain is better to absorb and store information in smaller amounts. German researchers reported in 2015 that microlearning improved memorization by 20%. Their study determined that when microlearning students took 28% less time to answer questions. In addition, the scientists found that the human brain cannot concentrate for long periods of time. People have short attention span – just eight seconds. Thus, the study of small amounts in short focused topics is the optimal solution. Micro-learning breaks the huge piles of data into separate pieces. Therefore, students easily grasp the information that they can apply immediately. In the mobile world of employment schedule becomes more dense, and people want to learn on demand, quickly getting effective information when they need it. They want to study anywhere, anytime. This may be a smartphone, or any other portable device, where they can find free time such as infographics. Therefore micro-learning with its concise and relevant content is ideally suited for mobile learning. Students can use it at your own place, when they are ready. Also get timely access to relevant, targeted information, students can quickly get what they need. Therefore, they can quickly solve problems that do not require urgent or fill gaps in knowledge. But at the same time microlearning has several disadvantages. Obvious advantages micro-learning in higher and continuing education.

1. Concentration of attention. Numerous studies suggest that the main problem of the younger generation distracted attention. The average time during which the current students can stay focused on one task, is only a few minutes, after which their brain starts looking for a new object.

2. Availability. A new form of training involves replacing traditional teachers of computer training systems. Special program on your smartphone or laptop to read you new material, check to assimilate and take the exam. This makes learning more accessible, cheaper and quality.

3. Mobility. Now, during the training, you will not be tied to one place. To pass the course it is not necessary to be present in the audience or even be physically present in a particular place. You can travel, work, get sick, and at the same time receive a quality education.

4. Modularity and flexibility. Micro-learning involves obtaining knowledge in the form of small blocks, each of which can be easily changed, rearranged or eliminated altogether. Thus, the course becomes more flexible and the information – more urgent.

5. Microlearning obvious flaws. Micro-learning designed for easily digestible micro themes and objectives. It is aimed at fast and efficient online training, taking into account the busy schedule. For this reason, it is not the best choice for complex tasks or skills. A more thorough job requires more time and effort to master. It can not be understood in just three to five minutes. However, micro-learning can be used as additional resources for full courses and disciplines. Short modules can increase the value of the course, reinforce the key ideas and important points. For example, a student can view the three-minute video or a short presentation for the rapid updating of knowledge. Microlearning not suitable for more advanced topics with various stages, skills and objectives. It is for this reason micro-learning becomes less effective when it comes to long-term goals, where students should go deeper into the subject. Therefore, simple tasks or individual skills are embedded in a complex process. You can combine microlearning, through repetition interval and practice as part of a broader course, to enhance long-term learning. Do I have to follow the trend micro-learning? Yes, microlearning is ideal for the modern mobile learning and busy schedules of the world. It gives a brief, accessible and relevant information at the right time. But it is important to limit its use where it is less effective.

2. MICROLEARNING AS AN EFFECTIVE TECHNOLOGY FOR THE DEVELOPMENT OF LANGUAGE COMPETENCE OF FUTURE LANGUAGE TEACHERS

The curriculum in the direction of "Secondary education" is a place where you can organize the work and develop the linguistic competence as a key, namely one of its components – the culture of speech. The traditional approach to the organization of education and the use of the audiences of higher education, and only those audiences – to master the language competence at the highest level – is not the only or best option. In fact, work on these skills requires a lot of time, individual and team work, personalization, so the work requires a different structure: e-learning, combined with distance learning, as well as in combination with the traditional. Within the learning management system using technologies microlearning students are placed in a half-controlled environment, where restrictions are looser than in the auditorium of the University. With distance learning and working with the course content, which is presented in social networks, particularly Facebook and Instagram, you can erase the three limitations to the audience: time, content and degree of personalization. All these elements are completely interrelated. More time allows you to perform more complex tasks, and perform a larger or more complex content. For example, if we talk about the development of speech culture of future teachers, is to possess such competence of the future teacher is necessary to make a systematic analysis, synthesis, which requires much more time than that is limited in terms of the training and specific audience and is tied to the training time.

More time also gives more autonomy when dealing with complex content and the choice of tools to solve problems. If we take the example of "the use of information", depending on the complexity, at first it may take a long time, if students do not have information technology time, interest is to keep their self-contained, one-on-one on the task and allow them to experiment in different ways to search for information and use it constructively and effectively. In this case, distance learning greatly increases the quality of the product, as a student – the future teacher is not afraid to deal with the task within a certain time. The student does not feel at the time of their search restrictions. Having more time also allows students to solve more complex problems and make them more interesting. The use of distance learning in the development of language competence as a key with the elements micro-learning technology allows students to make the most of information and communication technologies. But micro-learning involves joint activities of the teacher and the student: analysis, comparison, control, creating a new product, and so on. In this case, it may already own program microlearning or own digital content, which is displayed by means of modern information technology, for example, in popular social networks or online channels. But microlearning involves joint activities of the teacher and the student: analysis, comparison, control, creating a new product, and so on. In this case, it may already own program microlearning or own digital content, which is displayed by means of modern information technology, for example, in popular social networks or online channels. But microlearning involves joint activities of the teacher and the student: analysis, comparison, control, creating a new product, and so on. In this case, it may already own program micro-learning or own digital content, which is displayed by means of modern information technology, for example, in popular social networks or online channels.

3. EXPERIENCE IN DEVELOPING LANGUAGE COMPETENCE AS A KEY LANGUAGE FOR FUTURE LANGUAGE TEACHERS IN THE PROCESS OF IMPLEMENTING MICROLEARNING TECHNOLOGY

Cherkasy National University named after Bohdan Khmelnytsky prepares students with a degree in "Secondary Education", Bachelor's and Master's level. But in this article we offer experience in the formation of language competence as a key future teachers-language and literature at the stage of the Bachelor, namely during the third year of the Bachelor program. The formation of linguistic competence of future teachers directed all language courses program, in particular the fundamental aspects of the discipline "Modern Ukrainian language", applied discipline "Methods of teaching." In addition, the formation of linguistic competence as a key – this is the main objective of the course "Fundamentals of speech Culture ", which is taught in semesters 5 and 6, the number of hours: 18 hours of lectures and 36 hours of practical training. But for just this time it is impossible to ensure the development of the necessary skills for culture of speech. Therefore, this course we connected remote digital learning module – microlearning, which is offered to students in the form of content in social networks Instagram and Facebook in several micromodules "Language ecology'', "Microlearning language". Content module microlearning for the development of Ukrainian culture of speech can be found on the personal page of the teacher – Professor Tatyana Simonenko in Instagram and Facebook.

Microlearning was independent and was not included in the basic training module. The experiment lasted for one year of study. We used in the experiment 56 students of the Bachelor of two national universities in Ukraine: Cherkasy National University (34 students); Kherson State University (22 students). Experimental group – students of the Cherkassy National University. Students of the experimental and control groups at the same time during the year of study of the course "Fundamentals of speech Culture." This is the main course of the program. However, students of the Cherkassy National we offered microlearning module, which the content was presented in Instagram and Facebook, it is constantly updated, proposing new tasks and new high-quality information. In Instagram visual content distributed as a supplement of the text (80 words) in the MDM proposed rules of writing, the lexical meaning of the word and life example, when and in what situation using words.

Content developers have the authors of this article (Professor Tetiana Simonenko and Associate Professor Yuliia Nikitska). During the year, the students were asked more than 200 microtreatments that were focused on the development of future teachers-language and literature Ukrainian culture of speech (aspects orthoepy, spelling, vocabulary, grammar). The students in the experimental group (34 people) had no time restrictions on memorization, at Making a microtreatments this or that, but it is worth noting that the knowledge of quality control was carried out by an independent module twice during the year. According to the main discipline – "Fundamentals of speech Culture" 2 times during the year in Cherkasy National University and Kherson State University. The content was a progressive level of difficulty, but it was not coordinated with the tasks they received while working in the classroom: the module has been completely independent. The observed period of activity during which we present here some of the results and comments, was from September 2018 to June 2019. Basic skills of speech culture in which we focused, were:

– About spelling figure of speech;
– About pronouncing figure of speech;
– Lexical figure of speech;
– Grammatical figure of speech.

During the year we held several microtrainings on materials that were presented on Instagram and Facebook. Students paid more attention and interest to the presentation of the educational of the educational material on Instagram. One of the microtrainings for the training module lasted 3 sessions of 4 hours. Tasks were interactive, aroused interest in editing tasks. Quality control of knowledge was carried out in the form of text editing and tests.

4. EXPERIMENTAL RESULTS

4.1. Researchers estimate micro-learning use technology in the development of language competence as a key future teachers-language and literature

Table 1, figures 1, 2 below presents our assessment of skills needs within one year of study at the Bachelor program. We were given assignments to students who have been focused on the development of speech; In particular, priority was effective text as a product of the activity. First, the texts were not effective enough, and rightly so, as the students were beginners. Of course, these figures are quite subjective, but they have to show the importance of each skill. Table 1 shows that in the process of distance learning, we have paid great attention to the quality of the text, many of the tasks focused on transformation, addition, reduction, editing, analyzing the problem of communicative situations. Some of the exercises were with spaces that are needed to complete the dictionary, some require short written answers, and other – questions with multiple choice answers. Of course there were problems that required the student's creativity. The types of jobs on which the actions were different: images, texts, microprinting.

The instrument for measuring student competence in our experiment was as separate phrases and a whole text. Students in the process of experimental work were offered various options for editing, as well as the option of editing the text. For example (we offer in the original language: Ukrainian): на протязі дня – протягом дня, підніміть руку – піднесіть руку, розкрийте зошити – розгорніть зошити, слідуюча зупинка – наступна зупинка. These and other phrases were entered into the text for editing. It was the text that was the tool that made it possible to measure the lexical image of speech, grammatical, spelling, pronouncing.

Table 1.

Work on the formation of linguistic competence as a key in the module's system microlearning (index from 1 to 5)

Competence	**Bohdan Khmelnytsky National University at Cherkasy (34 students)**		**State University at Kherson (22 students)**	
	Experimentally group		Control group	
	The First control	The second control	The First control	The second control
About spelling figure of speech	3.8	4.7	four	4.2
About pronouncing figure of speech	3	4.6	3.2	3.6
Lexical figure of speech	four	4.8	3	3.9
Grammatical figure of speech	3.5	4.6	3.7	4.1

Source: Own work

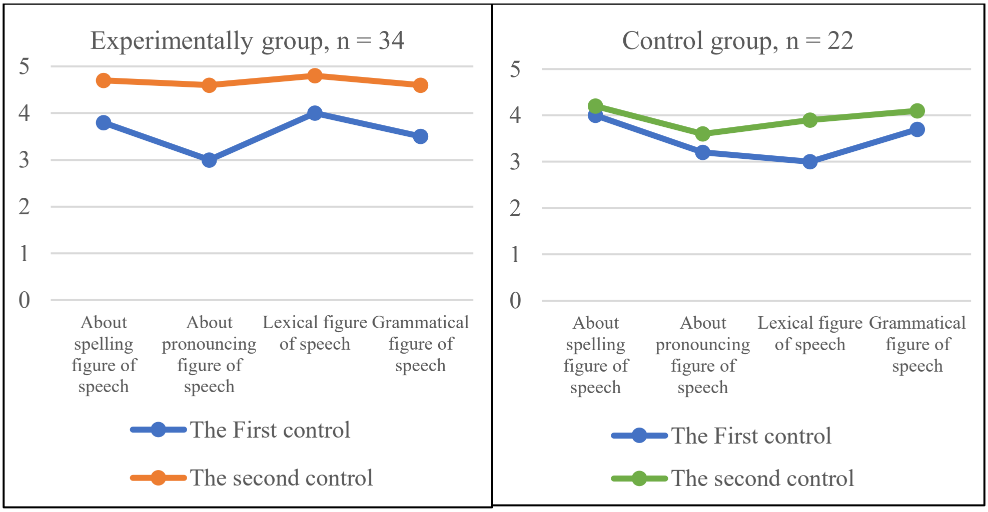

Figure 1. Work on the formation of linguistic competence as a key in the module's system microlearning (index from 1 to 5)
Source: Own work

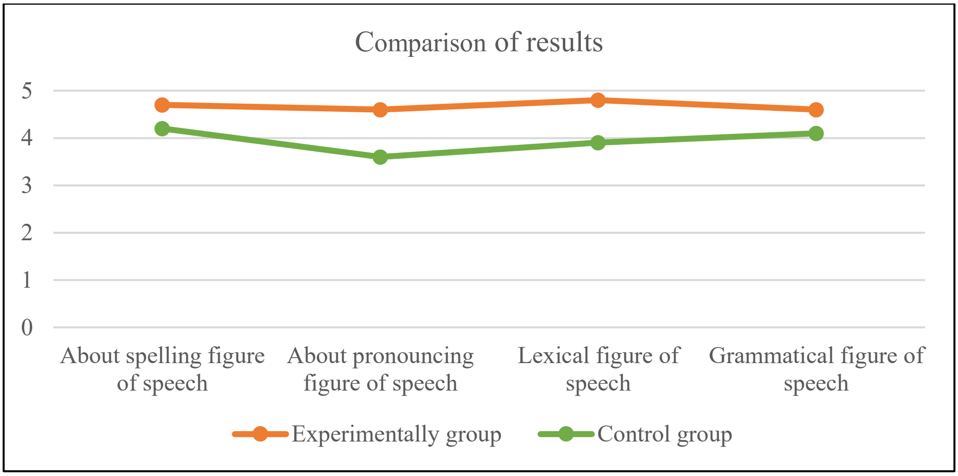

Figure 2. Work on the formation of linguistic competence as a key in the module's system microlearning
Source: Own work

Thus from the proposed table, we see that those students, who along with the main course was proposed micro-learning throughout the year with a serious content in the form of more than 200 tasks, and which was presented in social networks Instagram and Facebook, with which can work at any time, without being attached to the time at the university and to the specific time allocated to the study of language standards of classroom time, the students in the experimental group coped with the final control works much better. This is evidenced by the experimental data that we were able to fix after we analyzed the test papers (the first test at the beginning of training and the second test at the end of training) in the experimental and control groups.

4.2. The evaluation of the students and the learning outcomes for the development of speech technologies with microlearning

At the end of the year the students of the Cherkasy National University, that have students in the experimental group, we proposed to evaluate the work of formation of skills of speech and noted how microlearning content that is offered in social networks, as well as additional intermediate tasks and forms of control have helped them to achieve the goal of education and in the acquisition of specific language competences: spelling, pronouncing, lexical and grammatical.

Table 2, we offer data on the basis of the survey of students experimental group (34 students), which assessed the degree of importance in the acquisition of knowledge is microlearning content. We asked students how they assess the dynamics of its own competence is based on the traditional teaching in the system of the course "Fundamentals of speech Culture" and the work of an independent unit – content microlearning.

Table 2.

Importance microlearning technology to improve language proficiency as a key-score students (from 1 to 4) n = 34

Skills	1	2	3	4	Average
Spelling figure of speech	1	0	4	29	**3.7**
Pronouncing figure of speech	3	3	2	26	**3.5**
Lexical figure of speech	0	2	1	31	**3.8**
Grammatical figure of speech	1	1	3	29	**3.7**

Source: Own work

As you can see from the table, the students highly appreciated the importance in achieving the goal, there are about acquiring the competencies of culture of speech as a component of the common language as a key competence is developed content and organization microlearning. Students in the course of the conversation referred to a lot of the benefits of such training is: accessibility to digital resources anytime, convenient content presentation, that is, his "package", it is important that the content is presented in the form of microtexts. That is, as the experimental group, students say, you can quickly memorize information. One important point – this is a very convenient search for this information, because it is always at hand is one of the gadgets. Another positive aspect – the degree of confidence. Contents filled by specialists, in this case – the authors of this publication, which are specialists in the theory and practice of teaching.

CONCLUSION

The presented results encourage us to think that microlearning – is one of the most effective digital technologies that can be used as a supplement to the basic fundamental course. We believe that microlearning allows students to be more confident in the changing and transforming digital world, to be more in demand on the labor market and be more successful. We believe that for achieving these aims is the effective and constructive distance learning technology. This is confirmed by the results of experimental work. It is important to understand that microlearning as digital learning component – is a way of learning, rather than the type of learning. Microlearning – is a method which provide possibility for learning at that place where student is located. In this aspect experimental data confirms his effectivity during the process of development the speech culture as the component of the general linguistic competence of future language teacher.

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CHAPTER IV: ICT TOOLS – EFFECTIVE USE IN EDUCATION

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INTRODUCING THE YOUNGEST TO STEM EDUCATION IN TEACHERS' EXPERIENCES: ´KITCHEN LAB FOR KIDS´ PROJECT

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Abstract: *The article presents the results of research conducted with pre-school teachers as part of the international research project ´Kitchen Lab for Kids´ carried out within the framework of Erasmus+. The aim of the interviews was to find out if the teachers know what STEM education is and what skills develop in their pupils, how teachers develop STEM skills in their work, what conditions are needed to develop STEM competences in early childhood education, and what are the opportunities to develop scientific knowledge and skills through activity (learning) based on food/cooking in the early years.*

Keywords: STEM**,** preschool**,** preschool teachers**,** kitchen as a laboratory, KLab4Kids

INTRODUCTION

The modern world is changing very dynamically. This world requires teachers, including preschool teachers, to adapt the educational offer to the standards of the 21st century. We are currently observing that the demand for STEM (Science, Technology, Engineering, Mathematics) skills is still growing. Such education instils in the pupils a passion for exact sciences showing them that STEM is a fantastic adventure, giving them a chance for a good start in adult life.

James J. Heckman - Nobel laureate in economics in his works clearly stresses the importance of education from the first years of life:

“Early childhood development drives success in school and life. A critical time to shape productivity is from birth to age five, when the brain develops rapidly to build the foundation of cognitive and character skills necessary for success in school, health, career and life. Early childhood education fosters cognitive skills along with attentiveness, motivation, self-control and sociability—the character skills that turn knowledge into know-how and people into productive citizens.” (Heckman, 2013)

1. STEM CONCEPT APPLIED IN PRE-SCHOOL EDUCATION

The notion of STEM gained popularity at the beginning of the 21st. century. The acronym was coined by the U.S. National Science Foundation (NSF) and the term has been commonly used to denote common teaching areas. According to a definition proposed in a 2012 report: *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer* ‘STEM Education’ means “teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels - from pre-school to post-doctorate - in both formal (e.g., classrooms) and informal (e.g., afterschool specific for programmes) settings.” (Gonzalez, Kuenzi, 2012, p. 1).

All disciplines constituting STEM – that is: science, technology, engineering and mathematics - are closely and intricately interconnected. Despite their distinctiveness, the well-defined scope of knowledge they individually represent and the characteristic features each of these disciplines, they all share one common set of basic processes and practices, which can constitute an attractive area for a vast array of educational activities. It is the possibility of integrating various disciplines within STEM that should be seen as a crucial advantage of the concept. This approach helps to greatly enhance the educational process and make it become closer to the life and individual experience of a particular person.

The idea of education based on the STEM model supports defining and solving problems while promoting critical thinking. However, the core value of the approach consists in asking questions in combination with exploration and experimentation. STEM as an educational strategy is in keeping with the current trend promoting interdisciplinary and life-long learning. In addition, the concept is close to everyday life and its various situations and problems. STEM-based education, by developing interests and passions already in very young children, attempts to prepare the young generation to start their future jobs in the area. The STEM model increases learners’ motivation to study and promotes the feeling of agency in a person (Plebańska, Trojańska, p. 19).

The skills promoted by STEM Education are becoming an increasingly relevant component of the set of competences necessary for effectively functioning in the contemporary world – digitised and permeated with technology. They are already defined as fundamental skills, alongside the traditional ones – such as reading and writing. The literature on the subject has recently recognised a newly-coined term 'STEM-literacy'. The concept, interestingly, does not mean achieving proficiency in the scope of the four STEM disciplines that could simply be the sum of its constituents, but, instead, refers to competence synergy (Zollman, 2012).

The intertwining of individual disciplines may progress in a number of different ways. Children, when working on projects, gradually and systematically build up their knowledge about a specific topic in a given subject. According to some researchers, the most successful 'integration' occurs in a situation when a project is centered on one, dominant discipline, which is strongly emphasised. It should be, however, accompanied by problems and issues coming from other – background – disciplines (*Early STEM Matters. Providing High-Quality STEM Experiences* …, 2017, p. 7).

It should be noted that the majority of analyses and discussions focusing on STEM education traditionally referred to secondary or tertiary education. It is only recently that its importance has been properly recognised already in the early stages of pre-school education. Special emphasis is currently being placed on introducing children to science and technology from the earliest possible age, which should be accompanied by the development of openness and curiosity about the world.

Teachers and adults that support children in their development play an important role in the successful implementation of STEM education. This will become particularly obvious after reading the following guiding principles formulated by the authors of the 2017 report: *Early STEM Matters. Providing High-Quality STEM Experiences for All Young Learners*:

"1. Children need adults to develop their "natural" STEM inclinations.

2. Representation and communication are central to STEM learning.

3. Adults' beliefs and attitudes about STEM affect children's beliefs and attitudes about STEM.

4. STEM education is not culturally neutral." (*Early STEM Matters. Providing High-Quality STEM Experiences* …, 2017, p. 7).

In the context of this paper one should perhaps stress the relevance of the first two principles. Children may be willing to explore the surrounding world on their own, but they tend to quickly lose interest, grow impatient or show little enthusiasm when seeking answers to the problems they encounter. They easily give up efforts if the first one or two attempts at solving the problem fail. It is important that -

when confronted with such challenges – the child is accompanied by another person, who can help sustain their cognitive activity by defining the problem, directing the child toward the right answers, encourage persistence as well as supply valuable teaching aids and materials. Then, there is the commonly-held opinion that aptitude for such disciplines as, for example, mathematics or other sciences is inborn. Such views expressed by adults – whether teachers or parents – may create barriers that will impede the child's development and produce unfavourable learning conditions. A new outlook on this issue may bring enormous benefits as it will prevent the negative attitudes and beliefs that impose self-limitations on children. Therefore, the quality of STEM education may be improved through proper teacher training that will equip teachers and educators with all necessary knowledge and skills as well as provision of support and guidance in their teaching activity.

In addition, the authors of the above-mentioned report observe that: "Early childhood educators too frequently lack access to high-quality STEM education resources, lack guidance about what makes STEM resources high quality, and lack support for using available resources effectively. Educators need clear and concise information about what constitutes a high-quality STEM resource, and they need access to and support for implementing existing and newly-developed high-quality resources" (*Providing High-Quality STEM Experiences ...,* 2017, p. 28).

2. RATIONALE AND AIMS OF THE 'KITCHEN LAB FOR KIDS' PROJECT

The KITCHEN LAB FOR KIDS (KLab4Kids) Project, developed since 2018 under the ERASMUS+ programme, aims to collect and analyse issues related to STEM education at the pre-school level. The primary goal of the project is to facilitate the exchange of experiences and good practice in the scope of promoting active learning of STEM education (Science, Technology, Engineering and Mathematics) in European countries. The project outcomes should also stimulate and encourage teachers to explore modern interactive methods of teaching and learning that would support education within various STEM domains. Other important goals of the project include key issues related to methodological aspects and solutions, including pre-school level STEM education that would be both effective and attractive for children. In the times of an unprecedented technological development, one must not waste children's enormous potential. Small children, with their naturally curious predisposition, are eager to engage in exploration of the surrounding world. They experience it directly as well as through observation of adults attending to their daily routines. Thus, it seems reasonable to see the kitchen as an 'in-house' scientific laboratory, in which children will be introduced to the world of knowledge in an interesting and accessible manner.

The KLab4Kids Project is an initiative of 5 academic institutions from Poland, Italy, Ireland and Spain: Jesuit University of Philosophy and Education "Ignatianum", Libera Universita Maria SS Assunta, Fondazione Politecnico Di Milano, Universitat Internacional De Catalunya and Dublin City University. The project is coordinated by the Jesuit University of Philosophy and Education "Ignatianum" in Cracow.

The project is primarily addressed to pre-school teachers as well as pedagogy students and parents.

KLab4Kids aims to engage teachers and parents in assisting small children aged 3-6 in integrating knowledge from various areas as well as help to relate teaching and learning to the external world and individual interests and ambitions of every child. The project, which falls into the category of edutainment, seeks to combine preparation of meals, cooking and exploring various alimentary products with the acquisition of scientific knowledge. Alimentary products used for cooking as well as processes and phenomena taking place while performing various kitchen tasks are perceived as objects of research and child analyses. Also, one of the project aims has been defined as raising children’s awareness of hazards which they can encounter in the kitchen environment.

The outcomes of the KLab4Kids Project will include diagnosis and description of teachers‘ needs in the scope of STEM education in participating countries as well as the development of a Teaching Set. The set will contain a theoretical overview of problems of early STEM education, guidelines for the organisation of teacher training in STEM, search of supplementary materials and use of online resources, a detailed description of basic skills and key competences developed through STEM education and, finally, a range of typical teaching techniques and good practice, including games and experiments ready to use in pre-school classes. The set of tools and papers for teacher use will be provided as guidelines and recommendations for pre-school STEM education. The project will spin off KLab4Kids practitioner community – a platform for sharing knowledge and experience related to STEM.

Full description of the project is available on: http://kitchenlab4kids.eu/.

3. METHODOLOGICAL FRAMEWORK OF THE PILOT STUDY

A general principle to be followed with qualitative – i.e. questionnaire-based – research requires that the actual study is preceded by some kind of preliminary review. The literature on the subject distinguishes three types of preliminary studies. Even if the actual terms denoting them may vary, they have recently been referred to as reconnaissance, pilot study or pretest and trial test. In view of the assumed goals of the extended pilot study, the test of research tool (in this case – questionnaire) was to determine whether the questions included in the questionnaire yield relevant responses – that is: whether they produce specific information sought by the research team. Can one trust the obtained results as true, that is: are the responses not only relevant, but also accurate? (Grzeszkiewicz-Radulska, 2012, p. 117).

The pretest (pilot) study provided the research team with preliminary information concerning the validity of the research procedure adopted. The interviews were conducted on a small (10 persons) non-random sample. The sample was selected using purposive sampling according to criteria proposed by the researchers and adjusted to the specific character of the project. The studies were conducted in all countries participating in the project. This paper presents the findings of preliminary studies conducted in Poland. The results of pilot studies in other partner countries will be presented as part of other publications created as part of the project.

The study aimed to offer the research team an insight into pre-school teachers' opinions on STEM education. The main problem posed in the study has been defined as follows: What is the level of knowledge about STEM education among pre-school teachers? Specific problems have been formulated as follows:

- What are STEM skills?
- How do pre-school teachers develop STEM skills in their pupils?
- What scientific content and skills can be developed through food/cooking-based activity (learning) at an early age?
- What are the necessary conditions for developing children's STEM competences in early education?

The main research method used for the purpose of the study was the interview-based diagnostic survey, which was later used to develop the proper tool to be used in the actual study – survey questionnaire.

4. PRESENTATION AND DESCRIPTION OF THE STUDY FINDINGS

Initially, respondents were unable to explain the term STEM education. Once the notion had been defined by the researcher, they would describe STEM as the ability to integrate various scientific domains. This would be the process of teaching and learning which combines natural sciences with mathematics, technology and engineering both in pre-school and adult education, in formal and informal contexts. It is a blend of play, active participation, modern technology, mathematics and engineering. STEM education builds children's knowledge about the world in its social, natural and technological dimensions. Children are not fed with knowledge, they actively acquire it.

Respondents were further asked to clarify what they understood by STEM skills. The notion was mainly interpreted as a set of so called key competences, which are currently given strong emphasis. Other responses have been shown in Figure 1 below.

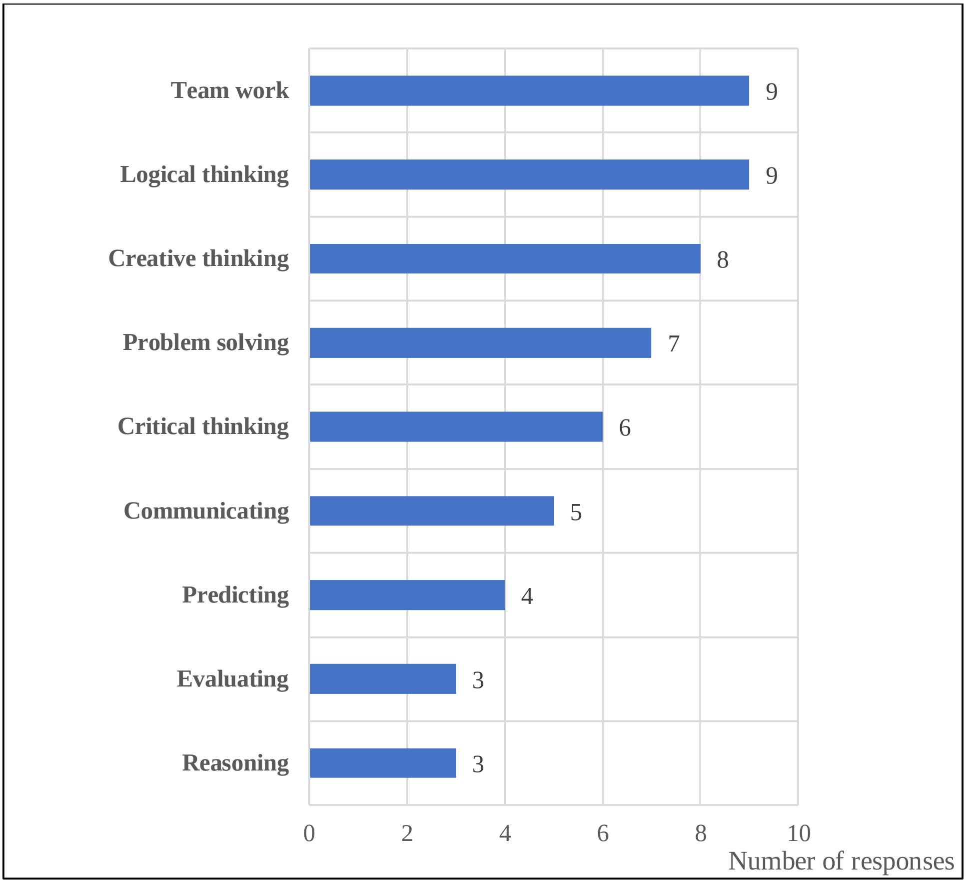

Figure 1. STEM skills in the opinion of the respondents
Source: Own work

All respondents, when asked whether developing STEM skills from an early age is important, answered in the affirmative. ‘Children are by nature curious and genuinely interested in how the world and its processes work’. ‘Equipping children with STEM skills encourages them to think ‘beyond here and now’ and thus develops them into more creative and abstract thinkers, helping them to take a more active approach to lifelong learning’. This will be of importance for them in their future lives. The introduction of STEM skills development offers a great advantage as children, from the very early age, develop creative and logical thinking; they acquire autonomy in practical activity as well as cooperative efforts. This approach to teaching engages the child, promotes ‘investigating’, critical and creative thinking, drawing conclusions and overcoming difficulties. Children are permanently engaged in activities, trying to address various problems in order to understand the world around them. The teacher can manage this natural curiosity and creativity, encourage asking questions and seeking answers. Social competences are of great importance too as children are encouraged to share ideas, they start getting ready for adult life, work and proper functioning in the society, in line with ‘new standards’. All of this boosts their commitment and motivation to act.

According to the respondents, as STEM skills are useful in everyday life, everyone should be equipped with at least basic level of STEM competences. This entails enhanced employability, better career prospects, the ability to cooperate in varied environments as well as the willingness to work toward common good and the ability to solve problems of daily life.

When asked how teachers in pre-school education develop STEM skills as part of their job, the majority of respondents answered that they involved children in the process of problem solving, that enables them to make use of various experiences and create their image of the world. ‘Children are small explorers... they have thousands of questions to ask, they never stop asking: ‘Why?’”. Teachers arrange inspiring situations that lead to new experiences which challenge children to come up with effective surprise, reflection, curiosity, cognitive conflict or motivation to verify knowledge through critical examination. Teachers also provide children with opportunities to undertake research activities, they make use of a host of learning methods to stimulate day-to-day peer work. Additionally, they create conditions conducive to the development of imagination and spatial thinking by, among other things, drawing, painting, creating and constructing. Teachers encourage the youngest children to design and build simple tools and devices and to create visual models (maps, charts and diagrams, layouts: parts of a room, complete room, house, nursery school, garden, playground); they devise a setting for discovering the natural reality through observation, experimentation and exploration. During the classes they use numerous materials and resources that require children to rely on their problem-solving skills and creativity. Equally importantly, children are exposed to the natural environment, stay in contact with nature, where they can get involved in research-type play, conduct observations and their own experiments. In their teaching and educational activity, teachers apply the method developed by Maria Montessori as it integrates various domains of science and approaches specific problems assuming various aspects and perspectives. In addition, the Montessori environment is supported by comprehensive materials, which enable children to develop their knowledge in the scope of mathematics, technology and daily life. ‘We run classes using sensoplast products. Children explore the world using their various senses’. Last, but not least, teachers embark on European projects, which integrate knowledge from various areas covered by the eTwinning programme, they develop pedagogical innovations.

Teachers, when asked to give examples of good practice in the scope of teaching/acquiring STEM skills at the pre-school level in children’s direct environment, reported weekly buffet breakfast events, where children select ingredients for sandwiches to be added to the menu. Children set up herbal mini-gardens in 'nature corners' or grow vegetables – later used for various meals - in nursery school gardens. Some schools organise monthly culinary workshops, during which children prepare dishes according to recipes contributed by the children themselves and their parents. 'We are doing a project on "Culinary travels around Europe". 'Once a year we arrange visits to a restaurant kitchen to see professional cooking equipment'. 'On sunny days we organise picnic parties and eat food we have prepared in the garden'. 'We ask children to bring simple kitchen equipment and together we learn how to use it'. 'We invite various professionals who tell us about their work: preparation of food (chefs), healthy food (dieticians)', etc.

The next question asked respondents about skills that are developed in children when conducting research related to food, nutrition and/or cooking. Respondents reported that children are introduced to nutritional values of various food products (including new flavours) and that they are given an opportunity to compose dishes (juices, salads, sandwiches, cupcakes) on their own. They reinforce 'positive' eating habits, overcome dislike for some healthy foods as 'meals you have prepared yourself bring more satisfaction and almost always taste better'. They explore the world around them from the kitchen perspective, through a host of various experiences. During group cooking sessions, children discover new interesting facts related to dishes and culinary traditions, they find out how to lay a table, what is used for eating, how one should eat and how to prepare food to make it safe, healthy, clean and tasty. Besides, they enjoy it a lot... they can pour, add, mix, blend and sprinkle things and do much much more. They learn to plan the next steps to be taken. They expand their range of vocabulary (children learn names of particular foodstuffs as well as the terminology related to food preparation). Children are given a boost of creativity (they can combine various products and are given space for experimenting, they learn that trying out new solutions is something positive).

Feedback on knowledge and science-related skills, which can be developed through active participation (learning) based on food and food preparation at an early age, has been graphically summarised below:

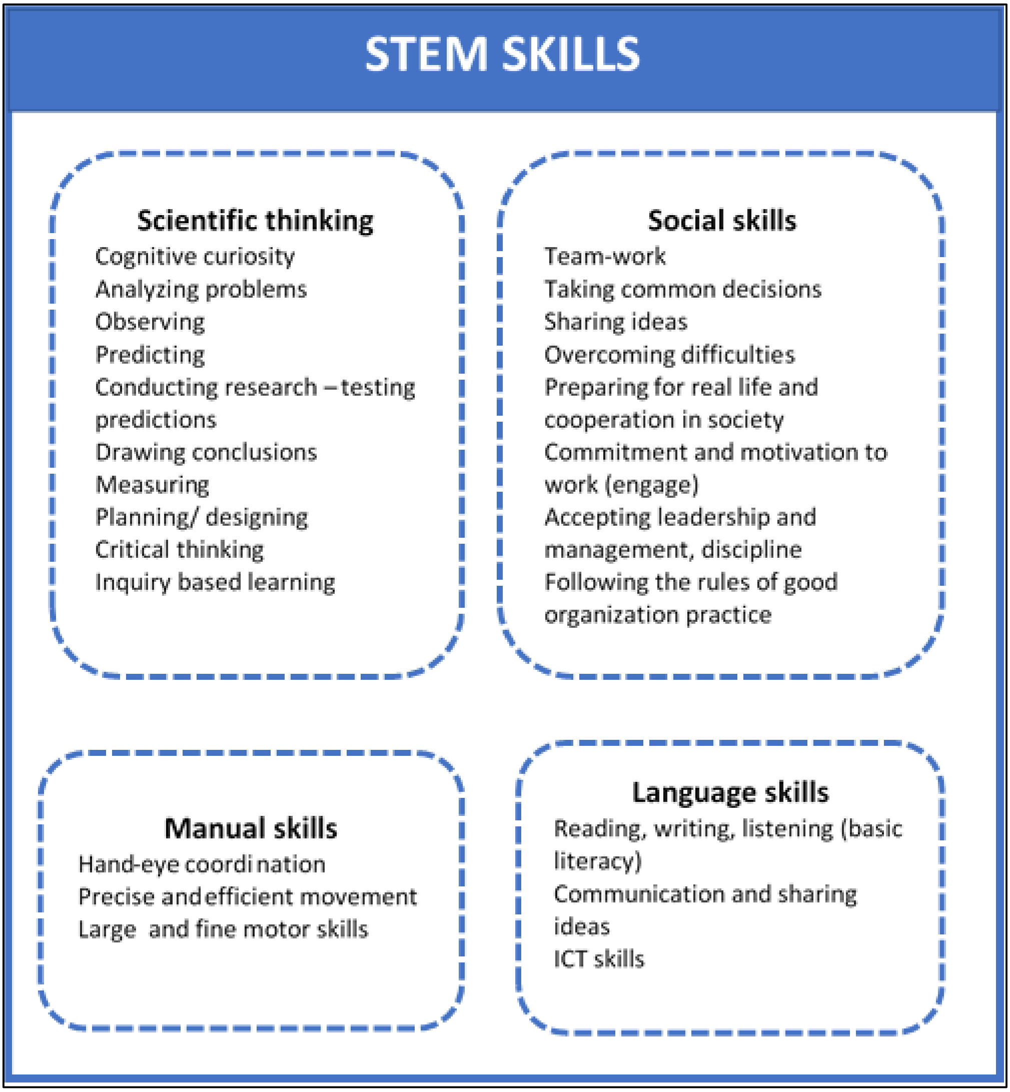

Figure 2. STEM Skills
Source: Own work

When asked about conditions necessary for successful development of STEM competences in early childhood education respondents mentioned several aspects:

- equipment available on site: teaching aids, materials and equipment, modern technologies, additional rooms for food preparation, easy and permanent access to kitchen equipment, kitchen utensils, recipes and ingredients, aprons for children;
- methodological background of teachers delivering such classes: ‘innovative approach’, methodological competences;

- organisation: small group size;
- cooperation with external contributors: parents, institutions, other teachers and nursery school personnel;
- safety: compliance with special safety procedures with regard to the use of the equipment, clothing, conduct etc.
- manners and behaviour: children are used to being given things ‘here and now’, without personal initiative (a habit to be modified).

The graph below shows respondents’ answers related to challenges (barriers) affecting the development of scientific knowledge and skills through food/ cooking-based learning.

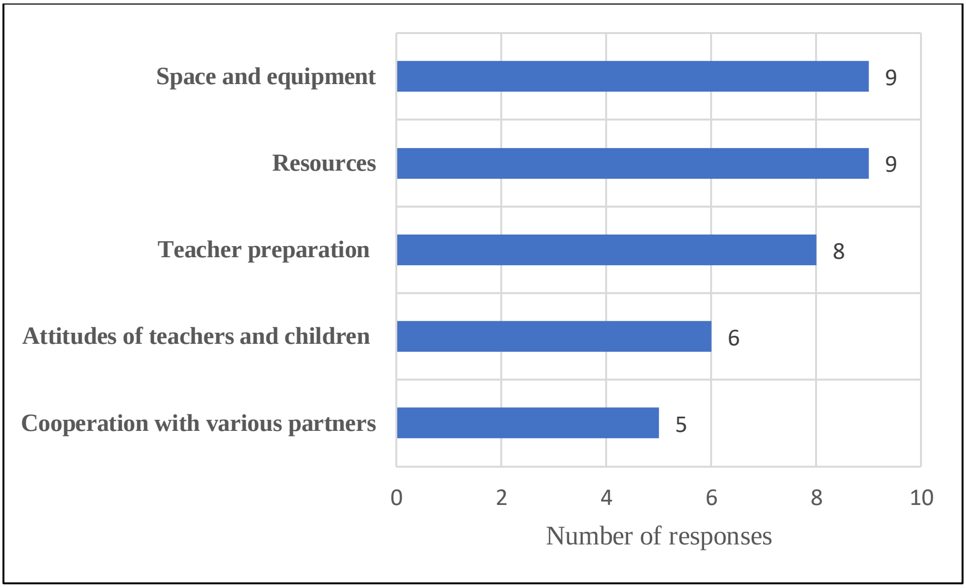

Figure 3. Challenges - to the development of scientific knowledge and skills through food/cooking-based learning

Source: Own work

The implementation of STEM is not easy. Obviously, lack of guidelines or methodological support for teachers interested in implementing STEM may complicate delivery of STEM-based classes. However, of equal importance is the right attitude, freedom given to children and their intrinsic motivation that comes with it as well as the enthusiastic teacher ready to undertake such duties with passion and commitment. Proper context must be set for children to experience such education in the first place. Then, it should be carefully adjusted to the child’s age and potential to properly attend to the child’s individual development.

The majority of teachers stated that when pursuing their degree programmes they had not been provided with any instruction regarding developing STEM skills in pre-school children. ‘When I studied, we focused more on theory and practice-oriented classes were only occasional’. In addition, any information on new forms and methods of teaching – named as ‘modern teaching’ – was very scarce. Besides, the current choice of training courses, seminars and conferences has little to offer in the scope of STEM education.

CONCLUSION

As suggested by the findings of the pilot study, teachers were initially unable to define what STEM education is. It was not until the researchers defined the notion that the respondents were able to indicate the meaning of the term as proficiency in solving problems, proposing unconventional solutions and responses, the ability to discover as well as give some deeper sense to what one wishes to express, the ability to develop interpersonal relations. In addition, STEM education fosters creativity, arouses curiosity, encourages active pursuit of knowledge and since learning is merged with play, it makes the learning process even more effective. During classes, pupils develop skills in critical thinking, thinking ‘outside the box’, making and testing hypotheses through experimenting. It also develops children’s manual skills, sense of space and time and workplace management. Teachers observe that developing these very skills is one of the main challenges to be addressed already at the pre-school stage. Delivery of the ‘Kitchen Lab for Kids’ Project constitutes can be an ideal way of learning as children acquire numerous skills they may rely on throughout their future lives. For this reason, the kitchen may become a home-lab, in which children may be introduced to the world of knowledge in an interesting and accessible manner. As it was stressed by the surveyed teachers, implementation of STEM is not problem-free. The scarcity of available methodological guidance or teaching programmes focused on STEM may constitute an obstacle when providing the course in a pre-school establishment. However, despite certain difficulties, teachers, in their day-to-day work with children, deliver a number of activities combining food preparation, cooking and exploring various foodstuffs with the acquisition of scientific knowledge.

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LEARNING STARTUPS AS A PROJECT BASED APPROACH IN STEM EDUCATION

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Abstract: *The paper is devoted to the issues of the project-based approach in STEM/STEAM education. STEM education (Science, Technology, Engineering, Mathematics) is an educational trend under conditions of which the curriculum includes enhanced natural science component with the use of innovative technologies. STEAM is a way to take the benefits of STEM by integrating it in and through the arts. The authors analyse the development of STEM/STEAM-education in Ukraine, compare competence level of educators and their level of using principles of STEM/STEAM education. The paper considers interdisciplinary aspects of STEM/STEAM education, in particular, implementation of robotics and 3D technology into the learning process as an important component of STEM education. The paper addresses the issue of gender equality, namely, wide involvement of girls and women in the IT field, STEM education in particular. The solution for attracting more women and girls to the STEM can be realized via incorporating Art and Design to the equation - to transform STEM into STEAM. The authors construct the model of engaging the Art component in creating the science-based methodological training system. The research also considers Learning StartUps as a project-based approach in STEAM education. The authors present examples of implementation of the project-based method in teaching 3D technology via Learning StartUps. Besides, the research shows how to involve Art and Design components in STEM education.*

Keywords: STEM/STEAM Education, Project-Based Learning, Learning StartUp, Robotics, 3D technology.

INTRODUCTION

The world where our children live and learn is rapidly changing. STEM education is one of the tools for training future specialists. STEM education is supported at a very high state level in developed countries (Tuzikova 2013).

The future is here, and it requires from us and our children to be well-versed in science, technology, engineering and mathematics (STEM). On the one hand, STEM education is the basis for training of specialists in the field of high technology.

On the other hand, STEM is becoming an increasingly important part for basic literacy in today's knowledge economy. Many countries (such as Australia, the United Kingdom, Denmark, Israel, China, Korea, Singapore, the United States and Japan) are developing national STEM education programmes.

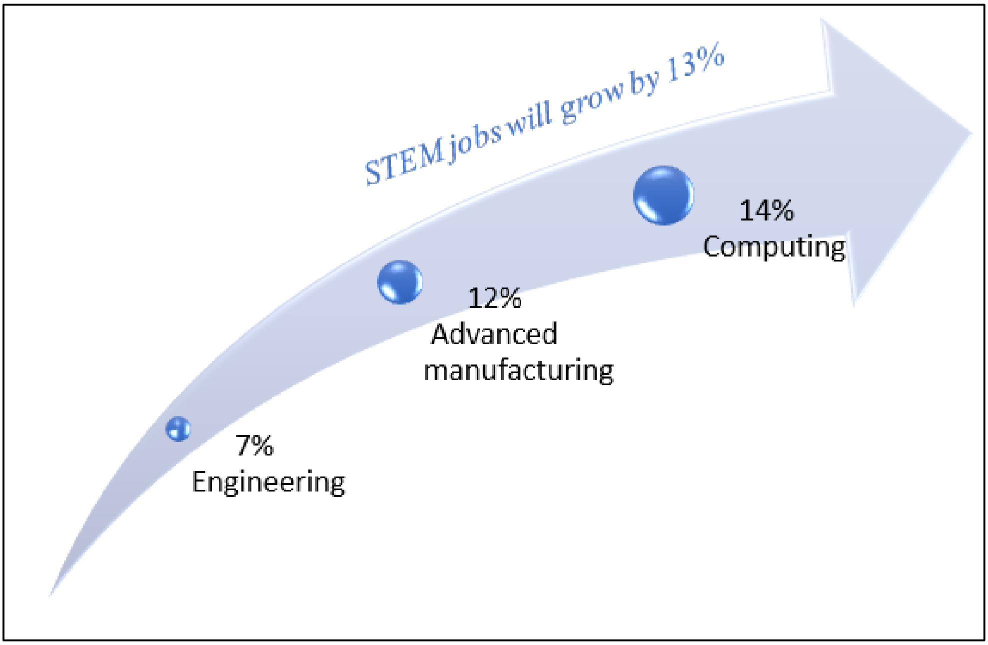

Figure 1. Estimated growth of STEM jobs between 2017 and 2027 in the USA

Source: Own work based on Education Commission of the States (http://vitalsigns.ecs.org/state/united-states/demand, accessed on 20 July 2019)

The survey of leading employers from around the world has contributed to the ranking of 10 high-demand competences up to 2020 with a prominent role in the ability and willingness to complex problem solving, critical thinking, creativity, management, coordination, cooperation, reflection, decision-making, service orientation, negotiation and cognitive flexibility. (Hassan, 2001).

The increase of all these high-demand competences is closely related to the STEM approach.

Forecast estimates show that in the period 2017-2027 the total number of STEM jobs will be increasing by 13%, compared with 9% of non-STEM jobs, especially in the sector of computing, engineering and advanced manufacturing (Figure 1). STEM occupations now account for 7% of all jobs across the Union, and the demand for STEM competences keeps growing.

However, in many parts of Europe, employers have difficulties hiring people with proper STEM skills, particularly ICT professionals. And the latest PISA data show that more than one in five 15-year olds in Europe are functionally illiterate in reading, maths and science. So, to keep Europe growing, we will need one more million researchers by 2020 (http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=key).

Unfortunately, Ukraine also has serious problems in this sphere. The Ukrainian innovation indicator as well as the level of technological availability of the labour force is one of the lowest compared with the rest of indicators of the country's competitiveness. These indicators are characteristics of the post-Soviet countries.

At the same time, innovation and modernized education and training are key priorities of the Europe 2020 strategy (Joint Report of the Council and the Commission on the implementation of the strategic framework for European cooperation in education and training (ET 2020), Official Journal C 417/25 of 15.12.2015). Building capacities and developing innovative ways of connecting science and society are priorities not only for many EU countries, but also for Ukraine. Schools are on the frontline in addressing this skills gap and mentioned above high-demand competences shortage by offering students the opportunity to learn STEM subjects to open up new career opportunities in existing and newly emerging sectors. These skills need to be developed from an early age. Schools should motivate children, with a special emphasis on girls, to learn maths and science. And we must help them to imagine working in these fields.

So, training future school teachers is strongly needed for many EU countries, and also for Ukraine.

National Pedagogical Dragomanov University introduces STEM approaches to the teaching-learning process too. There is preparation of the future Computer Science teachers via STEM approaches at the Faculty of Informatics. Also there are robotics laboratory and 3d printing laboratory to support STEM disciplines.

Research Focus: The focus of the research is on the project-based approach in STEM/STEAM education and interdisciplinary aspects of STEM/STEAM education, in particular the implementation of interdisciplinary links between STEM subjects, robotics and 3D technology. The research also considers Learning

StartUps as the project-based approach in STEM/STEAM education and shows examples of implementing the project-based method via Learning StartUps.

Research goal. Analysis of the implementation of STEM/STEAM education in Ukraine; comparison of the competence level of educators and their level of using STEM/STEAM education principles. Statement of the need in implementation robotics and 3D technology into the learning process as an important component of STEM education via Learning StartUps.

This paper addresses the following questions:

- analysis of the theoretical research background;
- analysis of the STEM/STEAM education as the most important educational trend among educators;
- rationale for importance of project-based approaches in STEM/STEAM education;
- comparison of the competence level of educators and their level of using STEM education principles;
- analysis of the StartUps in general;
- statement of the need in implementation of Learning StartUps as the project approach in STEM education.

The research also considers real-world examples of the implementation of Learning StartUps as the project-based approach in STEM/STEAM education.

Research methods. The authors use the following research methods and tools for the investigation (2017-2019 years):

- document and content analysis;
- analysis of the research papers;
- survey of the Ukrainian educators;
- learning process observation;
- experimental research of implementation of the project-based method in teaching 3D technology via learning StartUps;
- comparing of the research results.

342 Ukrainian educators (PhD students in the field of education, school teachers and university teachers from different Ukrainian regions) have taken part in the questionnaire. The questionnaire was designed during the project purposed to determine the competence level of educators and their level of using STEM/STEAM education principles.

42 Ukrainian students from the Faculty of Informatics (National Pedagogical Dragomanov University) have been involved in the experimental research. There were the Computer Science students (14 persons) and future Computer Science teachers (28 persons).

1. THE THEORETICAL BACKGROUNDS OF THE RESEARCH

1.1. STEM/STEAM education as the most important educational trend

STEM is a concept and educational system used by developed countries in various educational sectors to develop the skills needed for children and young people to be successful in the 21st century and contribute to the innovative development of the country as a whole. This concept originated on the request of business (primarily large corporations), which needed the most advanced professionals (Morze, Strutynska, & Umryk, 2018). The concept has involved a combination of different sciences, technologies, engineering and mathematical thinking (Figure 2).

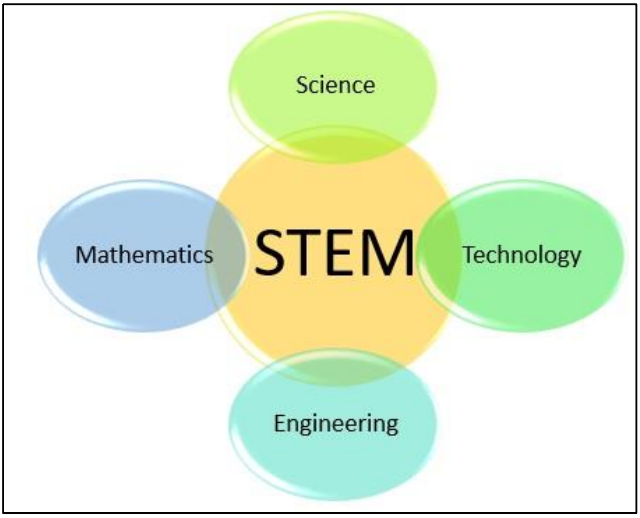

Figure 2. STEM education
Source: Own work

Interdisciplinarity is very important for STEM education. Interdisciplinarity in education is considered a pedagogical innovation (Volodchenko, Stryzhak & Khrapach, 2016). A key pedagogical problem of the development of STEM-oriented curricula is related to the component integration technology. On the one hand, this is about close disciplines. On the other hand, they are independent ontologies. Science is a way to know and understand the world around. Technology is a way of improving the world that is sensitive to social changes. Engineering is to create and improve devices to solve real-world problems. And mathematics is to describe the world, "analysis of the world and real-world problems in terms of numbers" (Meeth, 1978).

STEM education is based on the use of tools and equipment related to technical modelling, energy, electrical engineering, computer science, information and communication technologies (ICT), scientific research in the field of energy saving technologies, automation, robotics, intelligent systems, radio engineering, radio electronics, radio electronics, aerospace, etc. (Barna & Balyk, 2017).

The foreign experience shows that the introduction of STEM education is changing the economy of the country as a whole, making it more innovative and competitive. According to relevant research, attracting only 1% of the population to the STEM professions can increase the country's GDP to \$ 50 billion. The need in STEM professionals is growing two times faster than in other professions as STEM develops inclinations to research and creative activity, experimentation, team work skills, contributes to the formation of analytical, critical and innovative thinking (Institute of Education Content Modernization, 2018). In addition, it is predicted that 75% of the emerging professions will require STEM skills (Balyk, Barna & Schmiger, 2017).

Ukraine has great potential for the development of STEM education. This is evidenced by the materials of the World Economic Forum (Position of Ukraine in the Global Competitiveness Index 2017-2018, 2018) In particular, according to the quality of maths and science education, Ukraine is 27th of 137 countries (the statistics for 2017-2018).

Now the Ukrainian education is in the process of developing new standards and the concept of a new school. However, despite the fact that STEM approaches are implemented in many Ukrainian educational institutions, nowadays it is mainly out-of-school STEM education, i.e., various Olympiads of Natural and Mathematical Direction, activities of the Small Academy of Sciences, various scientific competitions and events for students (Intel Techno Ukraine, Intel Eco Ukraine, Ukrainian Festival of Innovation Projects "Sikorsky Challenge"), science picnics, hackathons, etc.

Therefore, reforming the natural-mathematical and engineering education on the basis of adaptation of foreign experience and proven practices of STEM education implementation is urgent (Barna & Balyk, 2017).

Some steps have already been taken in Ukraine. In particular, in 2015, STEM education coalition was formed in Ukraine. Key objectives of the coalition are (Memorandum on establishment of STEM-education Coalition, 2015):

- vocational guidance;
- implementation of programmes on innovative teaching methods in educational institutions;

- providing pupils and students with opportunities to conduct research and experimental work with the use of the modern equipment;
- competitions and Olympiads for self-realization;
- development of the international cooperation.

The results of the conducted research state that now STEM education is an educational trend. The research was conducted by the authors in two stages at an interval of one year by interviewing the Ukrainian target group educators (University teachers, school teachers, PhD Students in the field of education and students (future teachers) from different Ukrainian regions) to determine their willingness to integrate STEM education principles into the learning process.

159 Ukrainian educators have taken part in the first survey (during 2 months – July-August 2018). This was the first stage of the research.

It is important to note that the largest group of respondents are belonging to Computer Sciences and IT-related fields (71,8% of the participants). The distribution of respondents by educational role is shown in Figure 3.

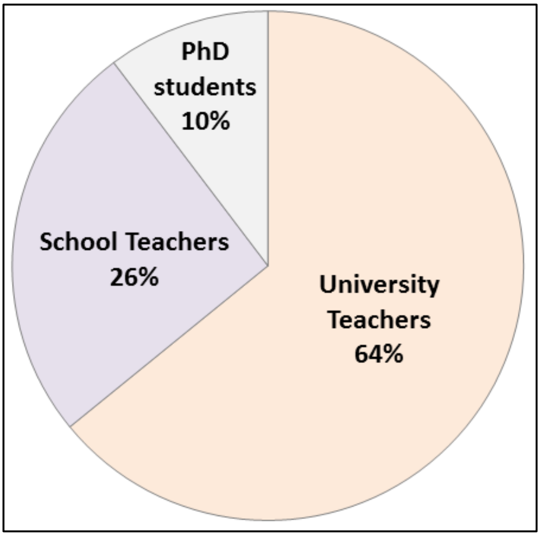

Figure 3. Distribution of respondents by educational role (2018 year - first stage of research)
Source: Own work

As we can see from Figure 3, the largest group of respondents is University teachers (64% of the participants –102 people). The number of school teachers is 41 people (26% of the participants). The smallest group of participants is PhD students in the field of education (10% of the participants – 16 people).

183 Ukrainian educators have taken part in the next survey (during 3 months – April-June 2019). This was the second stage of the research.

The largest group of respondents are belonging to Computer Sciences and IT-related fields (71,6% of the participants). The distribution of respondents by educational role is shown in Figure 4.

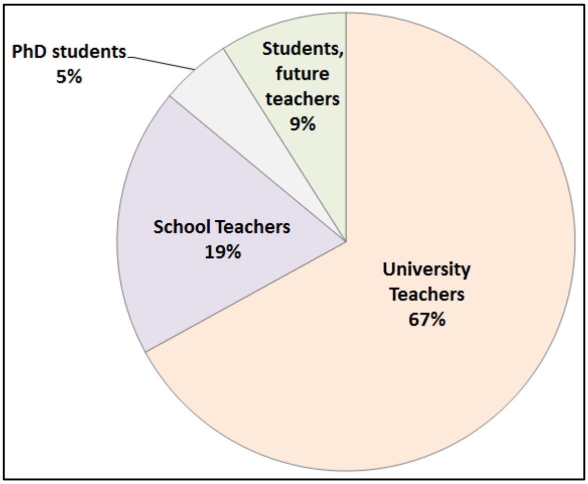

Figure 4. Distribution of respondents by educational role (2019 year - second stage of research)
Source: Own work

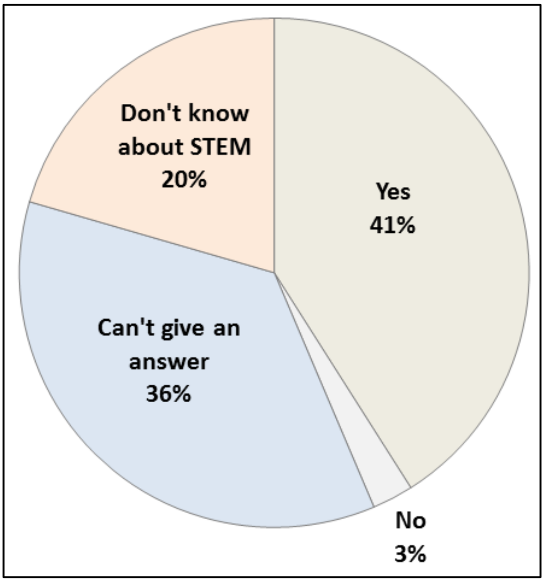

Figure 5. Survey responses on necessity to implement STEM education in Ukrainian educational institutions (2018 - first stage of the research)
Source: Own work

As we can see from Figure 4, the largest group of respondents is University teachers (67% of the participants – 123 people). The number of school teachers is 35 people (19% of the participants). The smallest groups of participants are PhD students in the field of Education (5% of the participants – 9 people) and students/future teachers (9% of the participants – 16 people).

The online questionnaire has been elaborated in the Ukrainian language by using Google Forms for gaining data on the Ukrainian educators' views and attitudes towards using the principles of STEM education in their professional activity. We have guaranteed participants that only anonymous data would be shared. Some important questions from both surveys are shown below.

Q.: *Do you think it is necessary to implement STEM education into the Ukrainian educational institutions?* (this question is from both surveys)

Survey responses on necessity to implement STEM education in the Ukrainian educational institutions are shown in Figure 5, Figure 6 (2018) and Figure 7, Figure 8 (2019):

Analysis of the data in Figure 5 has shown that probably most respondents do not have enough information about STEM education, because 20% of the participants do not know about STEM and 36% cannot answer this question (56% total).

Survey responses on necessity to implement STEM education in Ukrainian educational institutions distributed by educational role are shown in Figure 6 (2018 – first stage of the research).

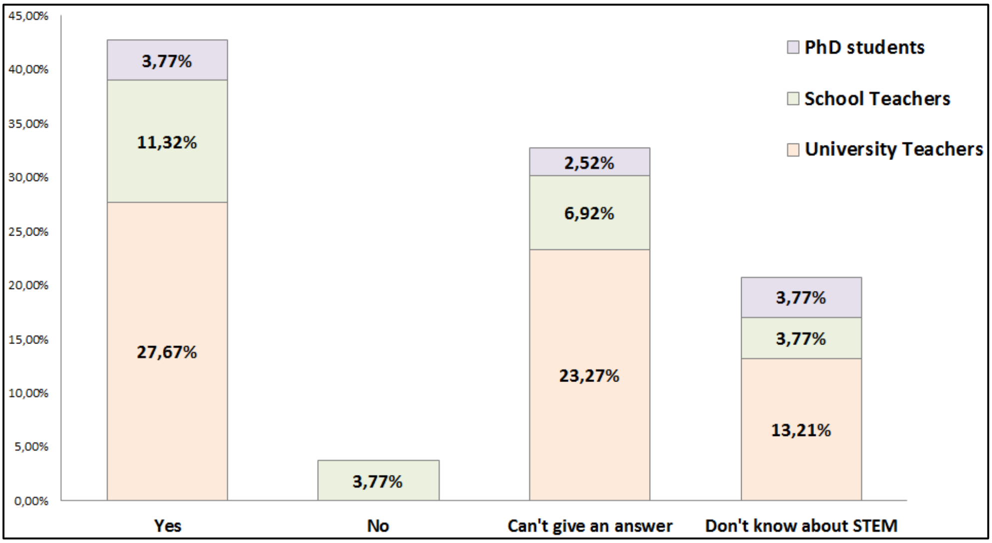

Figure 6. Survey responses on necessity to implement STEM education into Ukrainian educational institutions distributed by educational role (2018 year - first stage of research)
Source: Own work

Analysis of the data in Figure 7 has shown that probably most respondents still do not have enough information about STEM education, because 17% of the participants do not know about STEM and 24% cannot answer this question (41% total).

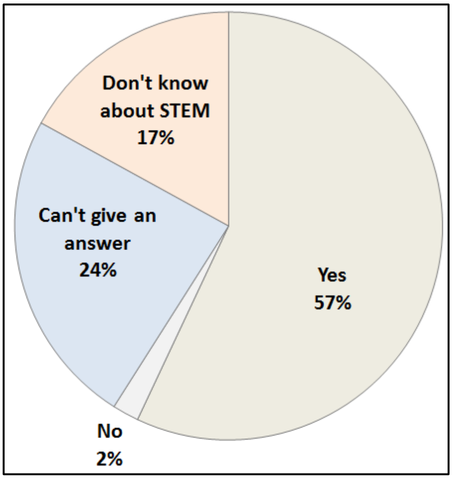

Figure 7. Survey responses on necessity to implement STEM education in Ukrainian educational institutions (2019 - second stage of the research)
Source: Own work

Survey responses on necessity to implement STEM education in Ukrainian educational institutions distributed by educational role are shown in Figure 8 (2019 – second stage of the research).

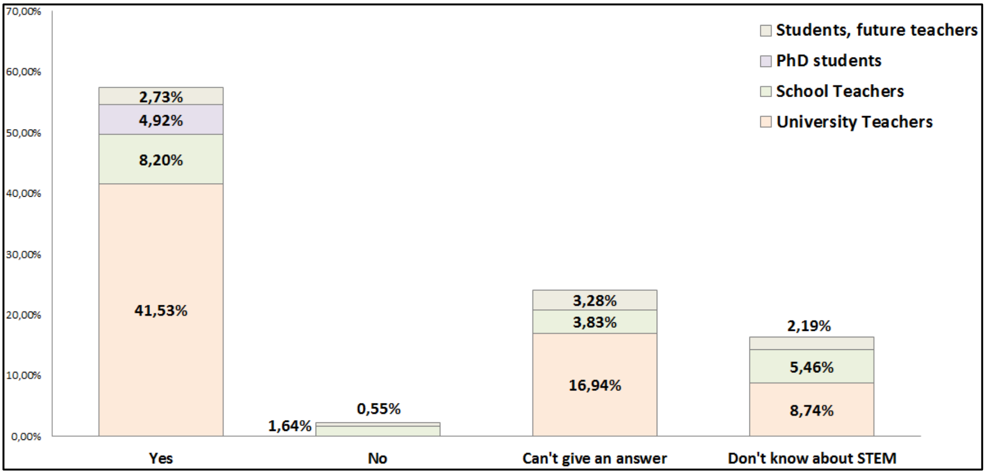

Figure 8. Survey responses on necessity to implement STEM education in Ukrainian educational institutions distributed by educational role (2019 - second stage of the research)
Source: Own work

Comparing the results of both studies (in Figure 5, Figure 6 and Figure 7, Figure 8), we can make a conclusion about increasing readiness level of using the principles of STEM education, because more and more educators consider the necessity to implement STEM education into the Ukrainian educational institutions (from 41% in 2018 to 57% in 2019). At the same time, the research results (2019 year) as seen in Figure 7, Figure 8 show that 17% of respondents don't know about STEM, which is 3% less than the results of the previous survey (2018). These results are indicative of an increased interest in implementation STEM education in Ukrainian educational institutions in general (see in Figure 5, Figure 6 and Figure 7, Figure 8).

Also, our second stage of the survey (in 2019) shows how many respondents already use the STEM education principles in their professional activities (see below).

***Q.**: Do you use the principles of STEM education in your professional activity?* (this question is only from the second survey of 2019 year)

Only 18% (33 out of 183 respondents) answered in the affirmative. The survey responses regarding using the principles of STEM education in their professional activity (distributed by educational role) are shown in Figure 9:

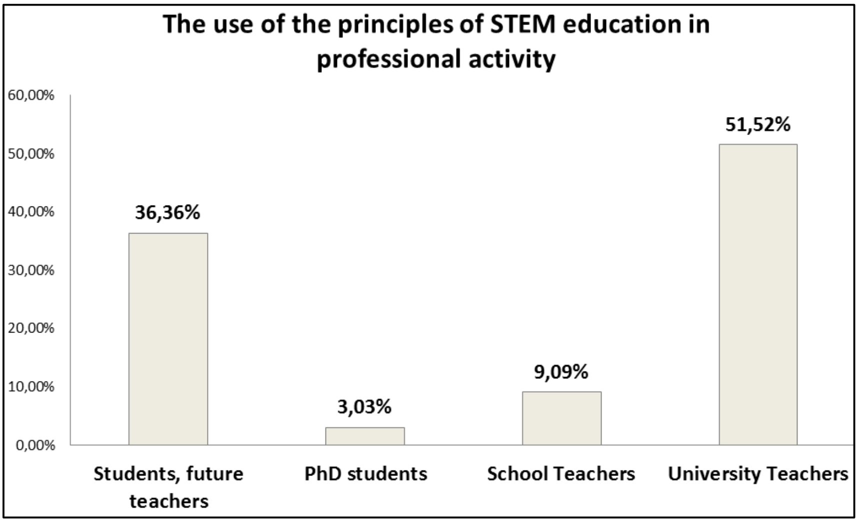

Figure 9. Survey responses regarding using the principles of STEM education in their professional activity distributed by educational role (2019 - second stage of the research)
Source: Own work

Thus, based on the abovementioned research, we can conclude that there is a need in making the Ukrainian educators familiar with the principles of STEM education, development of appropriate methodological materials for their retraining and advanced training. It is important for future teachers to include course modules related to teaching students with the use of STEM education principles. A significant number of affirmative answers (regarding their use of the principles of STEM education in their professional activity) among students and future teachers (36.36% - 12 people) are due to the fact that the majority of the respondents are master students employed in schools.

Let's consider interdisciplinary characteristics of STEM education in more detail. It is also important to involve the rapidly developing spheres to the main components of STEM education (science, mathematics and technology). We mean such areas as robotics and 3D technology. Robotics and 3D technology are versatile educational tools that are suitable for all ages (from elementary students to university students and academics). The use of educational robotics and 3D technology makes it possible to identify (at an early stage), students' technical inclinations and to develop them in this direction and in the direction of formation of STEM competences as a whole. Therefore, there is an issue of training specialists in the field of robotics and 3D technology, and in particular, training of future robotics teachers.

Analysis of recent research and publications is provided below. Despite the fact that at present there are many works (devoted to the use of STEM education) by both domestic and foreign scientists (N.R. Balyk, O.V. Barna, S.M. Brevus, V.Y. Velychko, S.A. Halchenko, M.A. Gladun, L.S. Globa, K.D. Huliaiev, S.M. Dziuba, V.V. Kamyshyn, E.Y. Klimova, O.B. Komova, O.V. Lisovy, N.V. Morze, L.H. Nikolenko, R.V. Norchevsky, M.A. Popova, V.V. Prychodniuk, M.N. Rybalko, O.Y. Stryzhak, I.S. Chernetsky, H.P. Shmyger, M. Harrison, D. Langdon, B. Means, E. Peters-Burton, N. Morel, J. Confrey, A. House, etc.), theoretical analysis of scientific works of leading researchers in the field of education and review of their experience (Morze, Ghladun & Dziuba, 2018) could show a necessity of creating a scientifically grounded methodological system for teaching of Basics of Robotics and 3D printing as a component of STEM education (Figure 10).

Considering STEM education as a science, mathematics and technology training, we should not forget also about the humanities. When this is about STEM education, there is often the question of gender equality while notice fields only for male or female. From an early age, girls and boys consciously and unconsciously prepared for different activities, interests and skills.

On the one hand, gender equality is a key priority set in the Member States and Associated countries in the European Research Area. The study conducted by the UNESCO Institute of Statistics shows that only 28% of the world's researchers are women (*en.unesco.org/genderequality, accessed on 20 July 2019*). That's why it is important that EU has the 'Women in Research and Innovation' campaign, which is a part of a wider strategy for gender equality in research and innovation (EU Prize for Women Innovators, gender equality in Horizon 2020 etc).

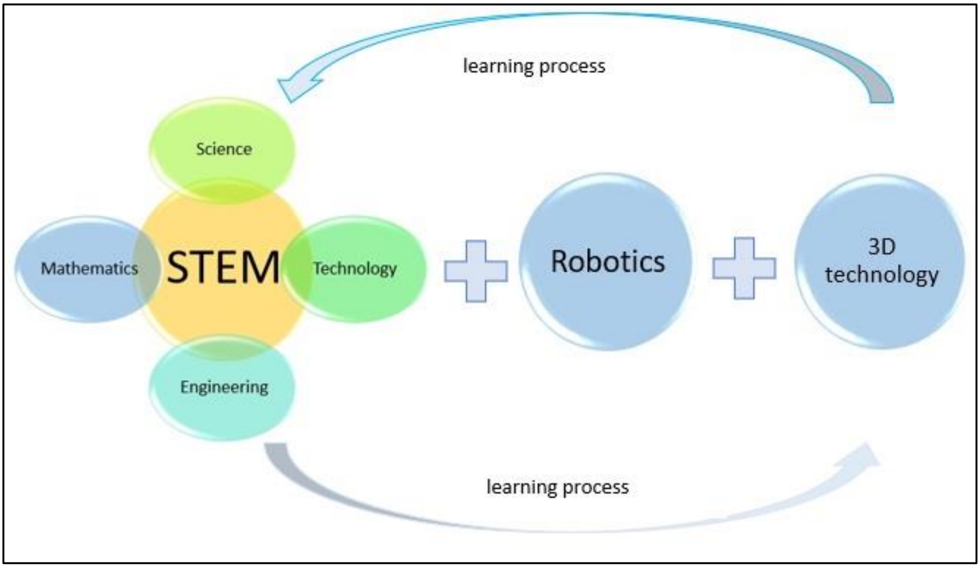

Figure 10. Implementation robotics and 3D technology into the learning process as an important component of STEM education
Source: Own work

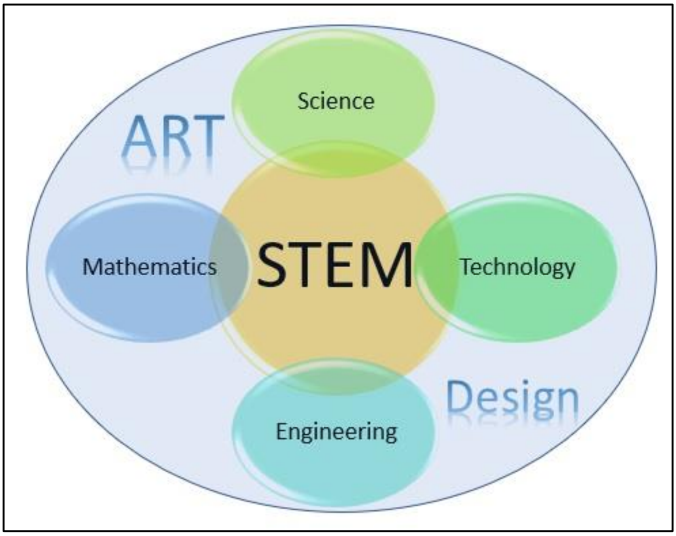

Figure 11. Transformation of STEM into STEAM
Source: Own work

On the other hand, there is a need in wide involvement of girls and women in the STEAM field. According to Labor Department statistics women hold only 16% of the nation's engineering jobs, 25.6% of Computer and mathematical occupations, 16.3% of jobs in Chemical area (U.S. Bureau of Labor Statistics, 2018, https://tinyurl.com/ybcqflfb, *accessed on 09 September 2019*). The solution to attract more women and girls to the STEM can be realized via adding Art and Design to the equation — to transform STEM into STEAM (Figure 11).

As mentioned above, Ukraine also has serious problems in these spheres.

According to the Ministry of Justice of Ukraine for 2018, the percentage of women and men in the IT field was respectively 20% and 80%. We need to learn the best EU practices in STEAM education and gender equality.

Universities are on the frontline in addressing these problems by offering students the opportunity to learn STEAM subjects. These skills need to be developed from an early age. Schools should motivate children, with a special emphasis on girls, to learn maths and science. We must help them to imagine working in these fields. Training of future school teachers, school teachers and school leaders is strongly needed for many EU countries, and also for Ukraine.

The experiment carried out within the research shows a necessity in the use of Art and Design components in creating a scientifically grounded methodological system for teaching of Basics of Robotics and 3D printing as a part of STEM education (Figure 12).

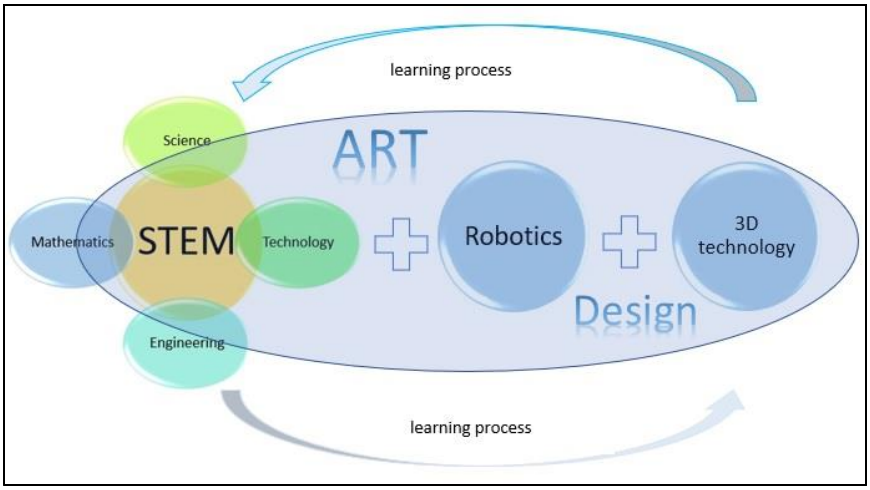

Figure 12. Use of Art and Design components in creating a scientifically grounded methodological system for teaching Basics of Robotics and 3D printing as part of STEM education
Source: Own work

More examples of creating the methodological system for teaching Basics of Robotics and 3D technology as part of STEM education (with the involvement of the Art and Design components) will be considered in the following parts of this research.

1.2. Importance of a project-based approach in STEM education

The Project-based Method (Project-Based Learning) is an active education technique on the basis of activation of educational and cognitive activity of pupils and students with maximum approximation to life (Movchan, 2016).

Project-Based Learning (PBL) makes a link between scientific practices and the real world (Hasni, Bousadra, Belletête, Benabdallah, Nicole & Dumais, 2016).

Besides, the application of the project-based approach in the learning process promotes the formation of students' teamwork skills, development of independent search and creative activity, the formation of cross-curricular competences.

One of the main goal of PBL is modelling real-world problems. Challenge is to get students to understand that issues in the real-world are rarely connected to only one subject. That's why the use of PBL in STEM education allows students to develop this interdisciplinary view. There was the reason for implementing PBL in teaching 3D technology. Some aspects of this experiment are considered below.

In the first year of 3D technology course (academic year 2017/2018), 16 bachelor students, future computer science teachers (in their 4th year) from the Faculty of Informatics (National Pedagogical Dragomanov University) have participated in the experiment. At the beginning of this course they were asked to do a medium-term individual project (duration 2 months). The main stages of the project are following:

1. *Project definition phase.* The goal is to study theoretical and practical aspects of using 3D printing technology.

2. *Planning*:

- determination of the sequence of the research stages (search for information about 3D printing technology, learning of software operations and creation of 3D models, making database of 3D models, familiarization with the principles of 3D printer operations, and printing of models);
- identification of information sources, collection means, data processing methods (analysis of scientific articles, Internet sources, documentation on the research topic, aligning the sources, creation of the information materials database);
- forms and means of presenting the research results (preparation of posters on the research subject, exhibitions of printed 3D models, presentations and speeches on the research results).

3. *Project implementation* (according to the sequence of the research stages).

4. *Project presentation* (presentation, demonstration of 3D models and 3D printer operation).

5. *Project implementation summary*.

The example of 3D-model designed by the student (Olexandr Pistiulga) is shown in Figure 13:

Figure 13. The example of 3D-model designed by the student (Olexandr Pistyulga)
Source: Own work

The experiment had a very positive effect on increasing students' motivation for studying. In addition, the students have mastered the latest technology (3D technology in general, 3D modelling, 3D printing etc.).
After good experiment results we have decided to use our previous experience for the next academic year and to expand it to teach 3D technology via learning StartUp projects. The example of learning StartUp project will be considered below (p. 2.2).

2. Learning StartUps as a project based approach in STEM education

2.1. StartUps in general. Examples of the famous Ukrainian Startups

The concept of a "Start Up" emerged for the first time in the 1930s in the United States, when two students, William Hewlett and David Packard, started a small company (now it is the world-renowned Hewlett-Packard company – HP). It was the first StartUp.

There are many definitions of the term "StartUp" in the scientific literature. Scientists interpret the term as (Vitlina, 2017):

– newly formed organization engaged in the development of new goods or services under conditions of extreme uncertainty;

- process of entry into market of a newly established enterprise with an innovative project, usually within short time and with minimal investment;
- new company in the initial stage of its development, which is created to realize a promising idea in order to generate high profits;
- temporary structure for sourcing of a large-scale, reproducible and cost-effective business model;
- company with a short history of operating activities;
- new companies that are under development and in the process of growing their business on the basis of new innovative ideas or emerging technologies;
- newly established company that owns prototypes try to organize production and launch of products to the market.

The most famous examples of startups in the world are: Airbnb, Amazon, Apple, Dropbox, Facebook, Google, Instagram, Microsoft, Paypal, Ryanair, Twitter, Youtube, Xiaomi, Uber etc.

Startup consists of three components, i.e., idea, team and funding (Figure 14).

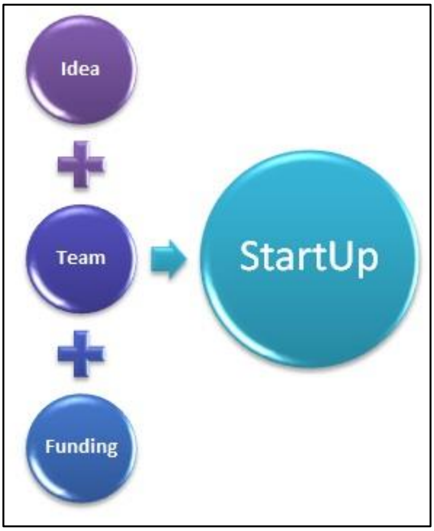

Figure 14. The components of StartUp
Source: Own work based on Oksenyuk, 2018

The main startup components are described in more detail in the study (Oksenyuk, 2018).

According to international of startup technologies experts, there are 5 stages of startup development (Figure 15), (Salamzadeh, Aidin & Kawamorita Kesim, 2015; Paschen, 2017; Oksenyuk, 2018).

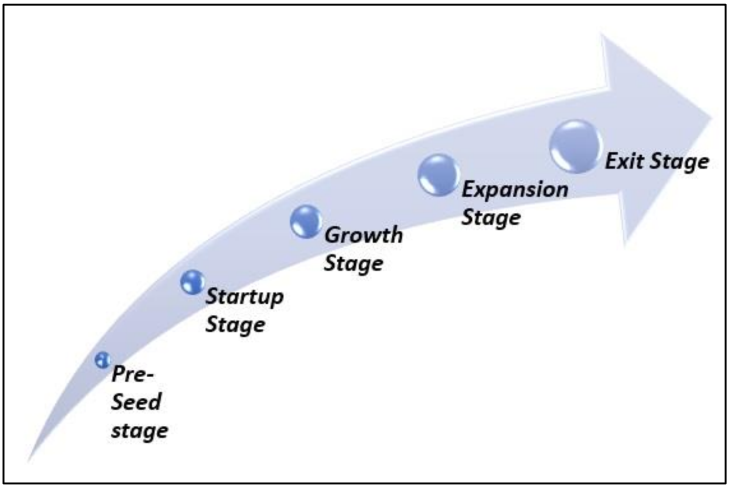

Figure 15. The 5 stages of startup development
Source: Own work based on Salamzadeh, Aidin & Kawamorita Kesim, 2015; Paschen, 2017; Oksenyuk, 2018

1. ***Pre-Seed stage***: A clear idea and understanding of target audience needs. Then it is necessary to study the market, prepare an action plan, develop a project prototype, search for investors.

2. ***Startup Stage***: An investor has already been found, the product can be marketed. It is necessary to prove its superiority over analogues. This is the time of many risks.

3. ***Growth Stage***: Startup stage where a project has survived in competition. The project is in demand and occupies a market niche established in the business plan.

4. ***Expansion Stage***: Business plan have been achieved. And the business is expanding to other markets, through the purchase of other startups in particular. The company's positions are no longer in danger, the products are in stable demand, and revenues are gradually increasing.

5. ***Exit Stage***: Project exit of the initial investors in the face of venture funds, and subsequent sale of the project. The company has reached the pinnacle of its own development. The investors abandon their stake in this business and selling it strategically to the strategic players.

The Ukrainian startups participate in the international conferences and exhibitions. It should be noted that 8 Ukrainian teams participated in the Consumer Electronics Show held in January 2017 in Las Vegas. The Ukrainian developers take part and win prizes of the international events: Eurasia Mobile Challenge, Mobile World Congress, etc. (Oksenyuk, 2018).

The most famous Ukrainian startups in the world are:

- **Viewdle** (2006 year): Startup on the development of image recognition and computer vision (Computer Vision). In 2012, Google has bought the Ukrainian startup Viewdle and used its development to search for images within the service (https://www.google.com.ua/imghp?hl).
- **Grammarly** (2009 year): The world's most popular educational service, i.e., the application for checking grammar and spelling in English (https://www.grammarly.com).
- **Augmented Pixels** (2010 year): Startup of augmented reality technologies. The company is among the largest suppliers (such as Apple, Google, Microsoft and Sony) of components for computer vision systems (Computer Vision). The system allows machines to detect, track and classify objects (https://augmentedpixels.com).
- **SolarGaps** (2015 year): Smart blinds with built-in solar panels. SolarGaps get solar power directly from the window. You can manage them with your smartphone. In this case the slats are automatically adjusted in such a way that it works as efficiently as possible even in different periods of the day (https://solargaps.com).
- **Ecoisme** (2015 year): Digital home energy management system with elements of gamification and socialization (https://ecoisme.com).
- **Kwambio** (2016 year): 3D printing of ceramic products. In April 2019, Kwambio, together with the WeFund Ventures Foundation, launched ADAM project. The main project goal is 3D printing of the bones and organs, as well as the creation of a virtual human body atlas from 3D scanned images of CT and MRIs (http://kwambio.com/#/).
- **Technovator** (2016 year): Wireless charging for mobile devices (https://technovator.co).

Thus, Ukraine can equally compete with the developed countries and become one of the leading players. The key to this is the considerable intellectual potential and sufficiently high standards of higher technical education in our country.

2.2. The example of students' learning StartUps via teaching 3D technology

Students of the Faculty of Informatics (National Pedagogical Dragomanov University) were asked to create Learning StartUp projects during the 2nd year of teaching the 3D technology course (2018-2019 academic year) to develop their technical creativity and entrepreneurial competence.

26 students have participated in the experimental research: 14 Bachelor Computer Science students (3rd year of studying) and 12 Master students, future Computer Science teachers (2nd year of studying).

At the beginning of the course, they were asked to do the medium-term group StartUp project (during one semester). Of course, it was difficult to implement all the stages of a real startup discussed in Section 2.1 within the learning process, so we have chosen the pre-seed stage for the creation of Learning StartUps.

Summarizing our own experience and research findings (Ghavrysh, 2016), we have defined the main stages of learning StartUp project. There are following:

1. ***Analysis of the Learning StartUp***:
   - description of the project idea (content of the proposed idea, difference between the product and existing analogues and substitutes);
   - description of the product design technology by which the project idea can be implemented;
   - development, production and testing of a product prototype.
2. ***Market analysis of possible sales of the products***:
   - list of technical and economic properties and characteristics of the product;
   - description of target groups of potential product consumers (market strategy development).
3. ***Organization of the Learning StartUp***:
   - drawing up a plan (schedule) for implementation of the Learning StartUp;
   - calculation of needs for fixed assets and intangible assets;
   - calculation of the planned production volume of the potential product, the total initial costs of launching the project and the estimated overall economic costs necessary for its implementation;
   - analysis of projected gains and losses and risks.
4. ***Presentation of the Learning StartUp results*** (presentation, demonstration of the product, its main characteristics, calculations of the planned volume of production, profitability of StartUp, etc).
5. ***Summarizing up the performance of the Learning StartUp***.

During the 2018-2019 academic year, some Learning StartUps were developed by students of the Faculty of Informatics (National Pedagogical Dragomanov University) through the teaching of “3D technology”. There is an example of the Learning StartUp “3D Puzzle” with the use of 3D printing technology. Students completed all stages of the Learning StartUp, provided relevant materials (idea definition, technology analysis, market analysis, StartUp organization steps, and additional profit analysis).

The most important components of the **Learning StartUp "3D Puzzle"** is shown below:

1. ***Idea***:

- 3D models making of recycled plastic (puzzles, toys, household items, various accessories, etc.);
- custom printing of lost / broken parts;
- technology of 3D printing using eco-friendly plastic.

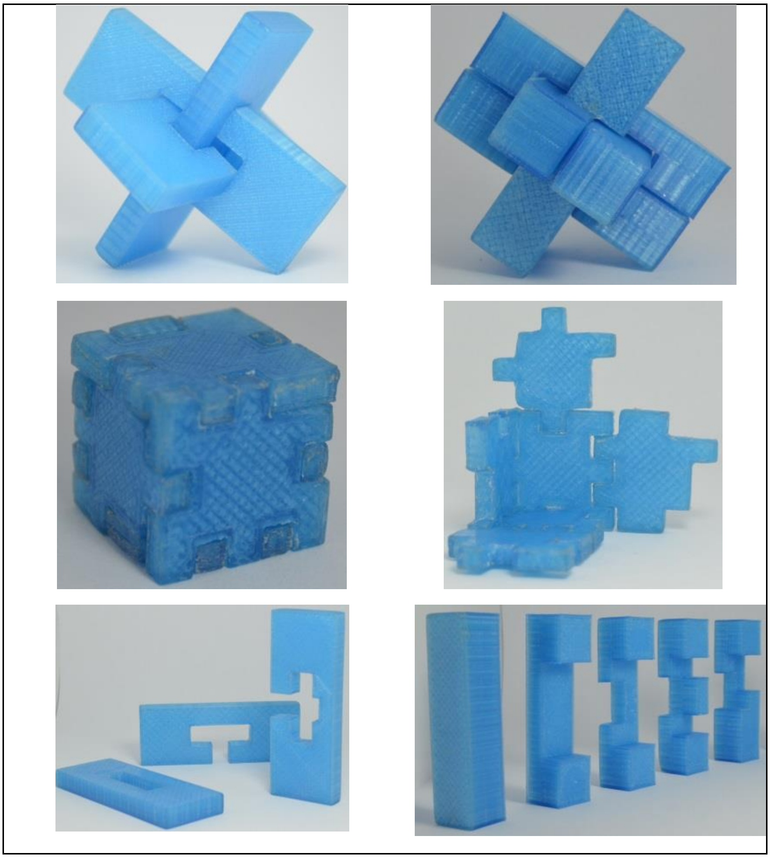

Figure 16. 3D models prototype of the Learning StartUp designed by female students (Marina Aksanyuk, Maria Semenova, and Anastasia Chorna, 2018)
Source: Own work

2. ***Analysis of technology for implementation of StartUp project***:

- analysis of different 3D printing technologies with regard to their cost, equipment cost (3D printer) printing time, etc. – opted for FDM technology;
- analysis of different types of printing plastics with regard to cost, durability, environmental friendliness and other characteristics – opted for PLA plastic eco-friendly ;
- analysis of the software for 3D modelling and 3D printing – opted for Blender and Cura;

– technical analysis of plastic processing equipment – opted for eco-project Precious Plastic (https://preciousplastic.com).

3. *Design, production and testing of a product prototype*:

– designing 3D models of several prototypes – 3D Puzzles (see in Figure 16);

– preparation of the working environment and 3D printed prototypes (determining the time of printing, consumption of plastic, electricity, etc.).

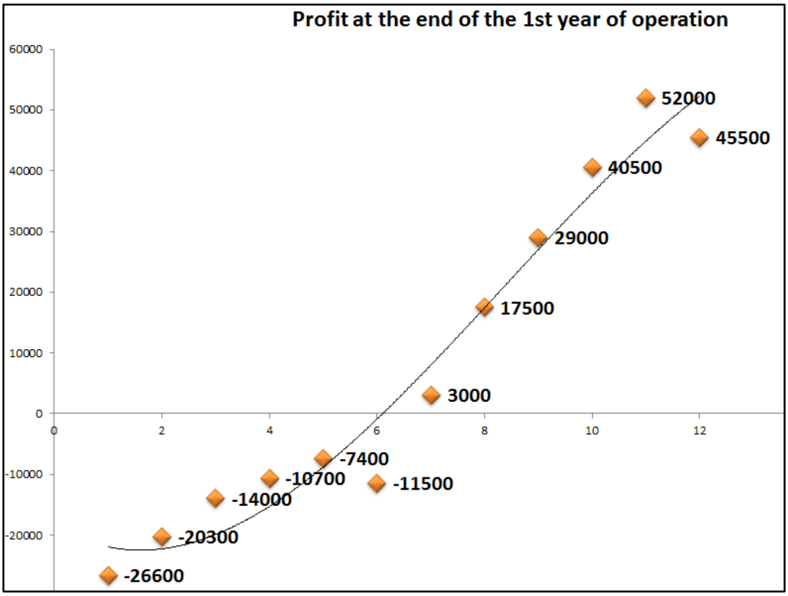

Figure 17. Planning profit at the end of the 1st year of operation
Source: Own work based on Learning StartUp "3D Puzzle" by female students (Marina Aksanyuk, Maria Semenova, and Anastasia Chorna, 2018)

4. *Market analysis of possible sales of products*:

– Target customers are:

– recycling companies;

– customers with custom orders;

– enterprises where recycled plastic is used.

5. ***Profit analysis***:

– the analysis of the profitability of this StartUp showed that the company will start to make profit at the end of the 1st year of operation (taking into account the purchase of plastic processing equipment), see Figure 17:

Figure 18. shows materials that were submitted to present the results of the Learning StartUp "3D Puzzle":

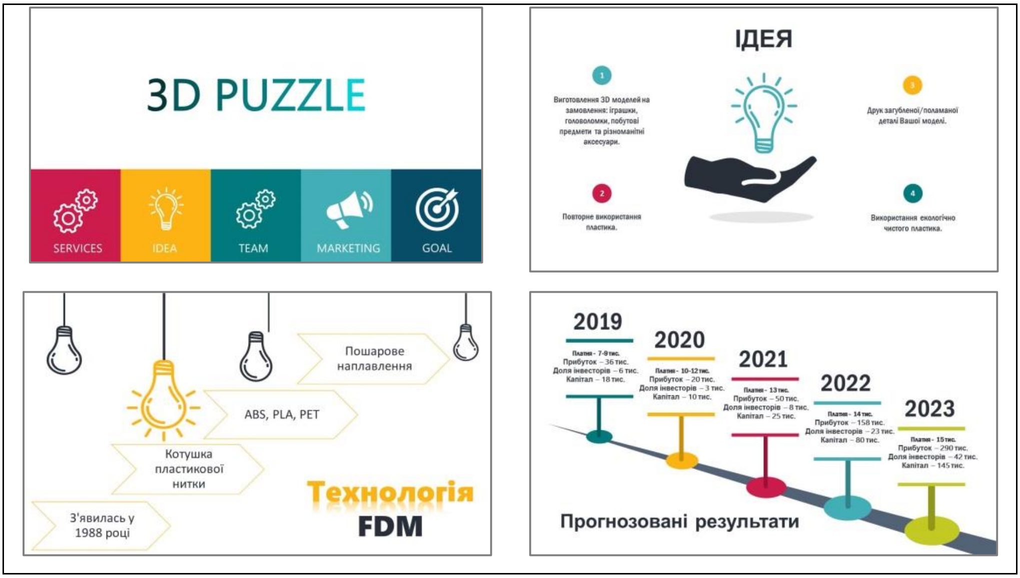

Figure 18. Some parts from the presentation of the Learning StartUp "3D Puzzle" designed by female students (Marina Aksanyuk, Maria Semenova, and Anastasia Chorna)

Source: Own work based on Learning StartUp "3D Puzzle" by female students (Marina Aksanyuk, Maria Semenova, and Anastasia Chorna, 2018)

According to the results of the evaluation of the Learning StartUps of the students, it can be argued that the vast majority of students, involved in the experiment (76%), have acquired skills in using 3D technology and knowledge about designing of the StartUp project. The research results also show a significant increase of students' motivation for studying. The increase in student motivation was confirmed by the fact that the number of students consulting with the teacher at off-hours doubled.

For the next year we are planning to involve students (designers of the best Learning StartUps) to participate in Ukrainian Festival of Innovation Projects "Sikorsky Challenge" (https://www.sikorskychallenge.com).

3. DISCUSSION

According to the research conducted, the authors propose ways to improve learning process with implementation of the Learning StartUps as the project-based approach in STEM/STEAM-education. The following issues (research results) have arisen.

a) expanding the experience of the use of Learning StartUps to increase students' motivation for other disciplines such as programming, information technology, robotics, etc.;

b) research on gender equality, namely, wide involvement of girls and women in the IT field, particularly in STEM education;

c) incorporating of the Art and Design components in the construction of the scientifically-based methodological system for teaching various disciplines, including the basics of robotics and 3D technology, as a component of STEM education;

d) including of individual components of the Learning StartUp in the final student thesis.

4. CONCLUSIONS AND PERSPECTIVES FOR FURTHER RESEARCH

The present needs require systematic training in the field of STEM / STEAM-education, that is confirmed by the experience and relevant research of the Ukrainian and foreign scientists.

The result of the research is the comparison of competence level of educators and their level of using STEM education principles for 2017-2019. Due to this, there are conclusions about increasing competence level of using STEM education principles in Ukraine, but more and more educators consider necessity to implement STEM education into the Ukrainian educational institutions (from 41% in 2018 to 57% in 2019).

Overcoming of the STEM/STEAM-gap requires correct identification of areas for further research which include awareness improvement and development of techniques for using the STEM/STEAM approach in the learning process, understanding of the conditions for the interdisciplinary aspects of STEM/STEAM education, in particular the implementation of robotics and 3D technology in the learning process as modern and important components of STEM education.

In addition, there is an issue of gender equality, namely, the wide involvement of girls and women in the IT field, particularly in STEM education. The research constructs the model of incorporating Art and Design components in creating the science-based methodological training system to address this issue.

The experimental research also provides Learning StartUps as a project-based approach in STEM education and describe examples of such StartUps. The research results also show a significant increase of students' motivation for studying.

Therefore, quality upgrading of STEM education could be reached through updating of the curriculum for future teachers of Computer Science, mathematics, physics and the implementation of interdisciplinary links between STEM disciplines, robotics, 3D technology and related fields.

Perspectives for further research are:

- increase of the awareness of educators regarding the interdisciplinary aspects of the STEM/STEAM-education;
- elaboration of a new survey for the Ukrainian educators to define their needs in STEM/STEAM-education;
- development of a scientifically grounded methodical educational system with the use of Learning StartUp;
- involvement of students, who are designers of the best Learning StartUps, into participation in different innovation projects such as Ukrainian Festival of Innovation projects “Sikorsky Challenge”;
- exploring ways to engage female students in STEM / STEAM-education;
- expanding the experience of the use of Learning StartUps to increase students’ motivation for other disciplines such as programming, information technology, robotics, etc.

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APPROACH TO THE CREATION OF A MICROLEARNING COURSE IN CODING WEB PAGES WITHIN THE LMS ENVIRONMENT

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Abstract: *For the creation of an e-Learning MicroLearning (ML) course "Creation of Webpages" we chose our ML concept slightly adjusted to needs of the subject matter. The paper describes the creation principles with examples and transformation scheme from the "classic" e-Learning design. Because of the nature of learning HTML and PHP coding, the course was extended by interactive coding exercises with prepared HTML code fragments. The created e-learning course also makes use of interactive microcontent units. The aim of this approach is to engage more active participation of student in the course and let them test coding directly within the LMS.*

Keywords: MicroLearning, e-Learning, Web Pages, coding, LMS.

INTRODUCTION

Today's world is changing quite fast and educational institutions have to react and keep pace. But they also have a responsibility to evaluate and carefully select what to implement as a new approach or tool. We would like to present evolutional approach to e-Learning, not an extremely revolutionary one.

If we say that today's world is changing fast, we mean society, its people and technology (services) that influence them. The Internet connection in mobile devices is nowadays quite common, mainly young people are in almost non-stop contact with their peers and the whole world. For younger generations internet connectivity, Web and social networks are services that they use on an everyday basis. In this world, complex study materials have to compete with interesting, obtained in small doses, available information that is almost always more appealing or interesting.

The classic approach to e-learning generally has the potential to attract students but many times is not flexible enough to follow up-to-date trends. It was some time ago that Nielsen defined the term “microcontent” (Nielsen, 1998) and this trend was later followed by the massive success of social networks. Social network Twitter (www.twitter.com) even explicitly restricts the maximum length of posts (at first limited to 140 characters, later extended to 280). We may find signs of “compression” in communication not only on the Web but also from lengthy book stories to movies, then shorter situation comedies, then maybe to comedians’ short sketches. On the Internet, “classic” articles were accompanied by (usually) shorter (and less formal) blog posts. Poe (Poe, 2011) speaks about the fact that short is what is connected with the Internet. Later emerged microblogs (around the year 2005), later best-known service working in a microblog-way became Twitter (founded 2006). The social network Facebook and its success was yet another step in the arrival of short content.

1. MICROLEARNING AND THEORETICAL BASE

1.1 Microblogging, MicroLearning and microcontent

In the Czech Republic, microblogging became for a short time a trend, several web-based services were established but eventually maybe for lack of authors or attention of readers were closed. Twitter can be definitely considered as successor - web service that created social network which makes use of short posts and interconnection of users and their messages.

In 1998 Nielsen (Nielsen, 1998) coined the term “microcontent”, meant headings (describing macrocontent) rather than the main content itself, though. Microblogging (first called *tumblelogs* in 2005) is connected with short pieces of text. There have been some examples of making use of it in education (Ahmad Kharman Shah, Latif Shabgahi, & Cox, 2016; Costa, Beham, Reinhardt, & Sillaots, 2008; Hauptmann & Gerlach, 2010). Alike ML, it is connected with informal learning (Ebner, Lienhardt, Rohs, & Meyer, 2010). It was Hug (Hug, 2005) who connected short text with the term MicroLearning and defined its main attributes. Lindner (Lindner, 2007) used the term “microcontent” and connected it with short pieces of content, in conjunction with Web 2.0. What he points out is the fact that microcontent is loosely connected, can be permanently changing, rearranging. In fact, many features can be found on the Web. Microcontent is also being connected with a rise of possibilities for masses to publish on the Internet (Buchem, Ilona & Hamelmann, 2010). If we look at microcontent as a part of the subject matter, the connection with learning objects (McGreal, 2004; Wiley, 2002) is obvious. They are also connected with granularity (McGreal, 2004) and are meant to be (re)used. The difference is that microcontent, in connection with ML is called a microcontent unit (MCU), aims to be focused on rather small parts of subject matter and in our view should, on the whole, make an e-learning (ML) course.

1.2 In search of a better way of learning

Although almost all educators agree that the learner should be in the centre of instructional efforts, many study materials are being prepared in a teacher-centred manner. We see it for instance in long textual materials that are easier to be prepared, cover more of the curriculum in a shorter time and making them accessible is to a wide extent also easier. Even though the student-centred approach shows better results (Freeman, Haak, & Wenderoth, 2011).

With the decision to focus efforts to maximize learners' gain, the test delivered before instruction (Grimaldi & Karpicke, 2012) shows interesting results. Applied are pre-tests that enhance subsequent encoding (Wissman, Rawson, & Pyc, 2011). The question is how is subject matter (as a whole) step by step being transferred to the mind of a student. A temporary structure that is by the time being extended and adjusted would be understandable. As to course structure, previous results show that active engagement of students makes them more skilled learners (Freeman et al., 2011). That is one of the motives that moved us to make use of (and enhance little bit) what is today called ML.

ML is usually being connected with a change in the way people communicate and in the way they can access all sorts of information (Bolka & Langreiter, 2006; Lindner, 2007) that the Internet offers. What we see as similarly important is the learning theory's perspective. There exists Miller's Magical Number (7+2) (Miller, 1956) or number four plus one (4+1) (Mathy & Feldman, 2012) that says that learners' short-time memory and capacity is limited. Following these findings, we can create an e-learning course that suits better students' current needs.

2. CREATING A MICROLEARNING COURSE IN AN E-LEARNING WAY

Most approaches to ML are mobile-based ML (P. A. Bruck, Motiwalla, Simons, Foerster, & Jonker, 2015; Peter A. Bruck, Motiwalla, & Foerster, 2012; Cates, Barron, & Ruddiman, 2017; Gabrielli, Kimani, & Catarci, 2006; Gassler, Hug, & Glahn, 2004; Göschlberger & Bruck, 2017; Jahnke, Lee, Pham, He, & Austin, 2019; Nikou & Economides, 2018). We also understand the indisputable need to support mobile devices and the benefits it brings. Because of the use of LMS Moodle as the main e-learning tool (at our University) – well known to students – we decided to create an ML course in this environment. LMS Moodle with a well-chosen template is responsive, so it meets the need for support for mobile devices. Because of the nature of some content types (e.g. interactive videos) they are not best viewed on devices with too small (narrow) screens. The solution is to use a mobile device in landscape mode.

In addition to Hug's (Hug, 2005) ML parameters, we added emphasis on interactivity, multimediality, and integrated quiz questions. The potential of LMS Moodle in the use of interactive content are quite limited, so we made use of H5P (www.h5p.org; based on HTML5 and JavaScript) that adds several interactive educational content types. In a variety of H5P content types, we mostly used “Course presentation”, “Interactive video” and “Quiz” (that supports almost any of supported testing tasks). We set a limit that one MCU should be around 5-7 minutes long. If the content length is not easily measurable (e.g. text, images), the time needed for its completion should be similar. Another applied constraint was connected with a number of terms. If they were important for the course we limited them to approximately 5-7 per MCU.

2.1 Structure of the topics of the MicroLearning course in dynamic web pages’ basics and use of MCUs

The course consists of eleven topics that cover the creation of dynamic webpages (Introduction to web pages, HTML, HTML and CSS, CSS positioning, JavaScript, Basics of PHP, PHP and Forms, PHP and MySQL, Saving Form data to DB using PHP, PHP Functions, Form Validation). The structure of each topic consists of compulsory parts set by the university regulation, among them are learning outcomes, keywords, study materials, (optionally) examples, summary, control questions for students’ self-evaluation and a test. MCUs themselves are then inserted in the study materials section. Generally, one unit looks like a normal Moodle-like e-Learning course. But the main difference lies in the used smallest parts – MCUs. They were placed in the course using Moodle’s activity content type (H5P activity specifically).

The results of the research we have recently finished showed that students did better in the factual knowledge test (Polasek & Javorcik, 2019) if they used the ML course in comparison with the “classic” e-Learning. The difference was statistically significant. Taking this into account we decided to utilize the gained experience and create a similarly based ML course for the subject dynamic web pages’ basics. Each unit consists of mainly MCUs (on average 10 per unit) – besides summaries of e.g. protocol commands, etc. – and at the end of each unit with a summary quiz. For the creation of MCUs, we employed the below mentioned H5P content types.

2.1.1 Interactive videos

In the beginning, as an introduction into a given topic, it is suitable to make use of video, which, by combining images, animations and various sketches, makes learning less limited by mere textual information. The intention is to grasp the learner’s attention and employ as many senses as possible. Because video (animation) creation is a lengthy process, good sources of videos are public video services like YouTube. Unfortunately, because of the language barrier (most of our students prefer Czech to English), the use of Czech subtitles is then a must.

These videos are turned into interactive tools by enriching it with various interactive elements. One of the basic devices are bookmarks, that give students the opportunity to skip parts, get to a certain point that student finds important, etc. We found it good to mark the beginnings of the main parts of videos and enable viewers to navigate within them. Videos themselves are very good tools, but we think that because of the lack of structure their cognitive potential may not be fully employed. Bookmarks in fact virtually chop quite short videos (maximum 5-7 minutes) into even shorter parts – seconds long, that cover only one specific detail, one piece of information, etc. We also inserted into videos short texts, that point out the key topic of a given part, important fact or give headings to video parts. They also can be used to translate texts that are not covered by subtitles.

Within interactive videos other types of H5P objects can also be used, mainly various quiz questions and tasks. Suitable are multiple-choice questions, drag the words or fill the gaps kind of tasks. We placed them at the end of particular parts to reinforce key facts or at the end of a video for summary revision.

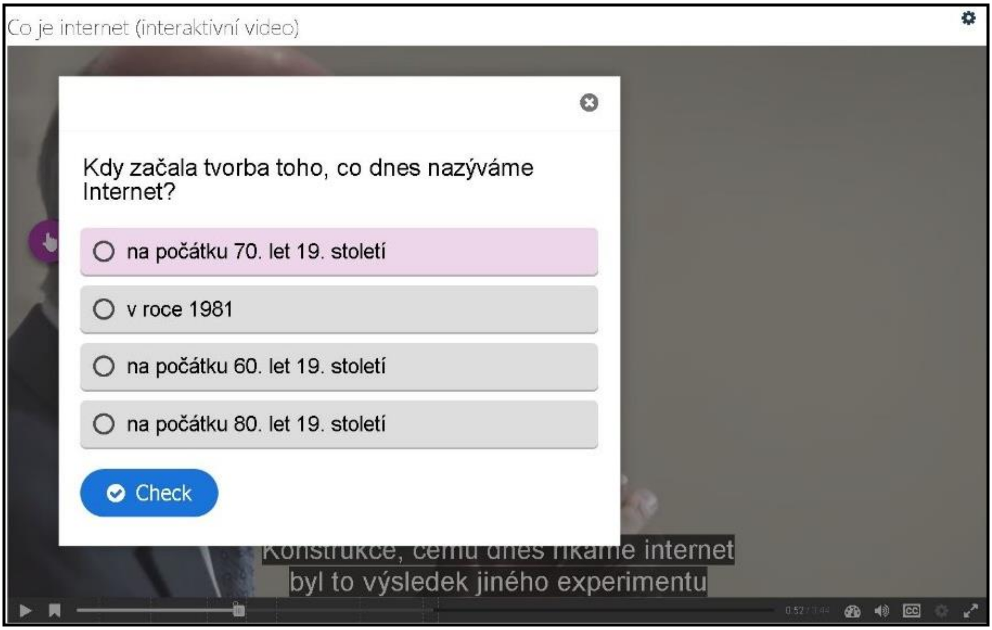

Figure 1. Interactive video with subtitles and displayed quiz question
Source: Own work

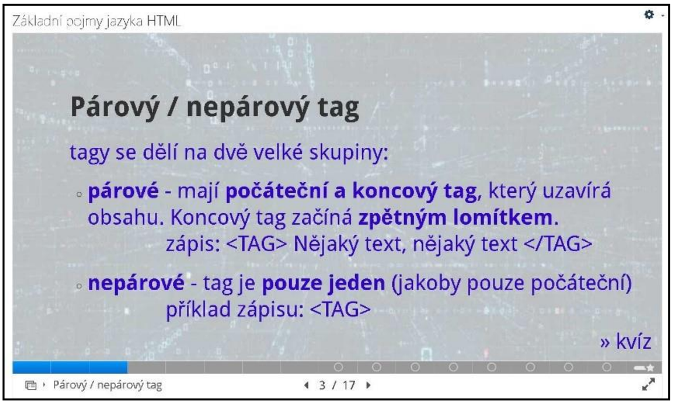

Figure 2. Interactive Course presentation as MCU with 7 terms and 8 quiz questions

Source: Own work

2.1.2 Course presentation with interactive content

An interactive course presentation was used as the main content type for MCUs. Unfortunately, if used just as a frame for text delivery they do not meet their full potential. A simple use can be as follows – a linearly connected chain of slides with text. But if slides are properly interconnected by hyperlinks, then also non-linearity can be employed. The approach we chose is to create this MCU with a limited number of slides (approx. 3-4 excluding title slide), without links, or when consisting of more slides (5 or more) interconnecting appropriate parts (slide with linked quiz questions).

The supported content types for the course presentation MCUs are, besides text and again various quiz questions, also videos, images, audios, even interactive videos. When using Course presentations, we made use of text slides combined with quiz slides.

2.1.3 Quiz (Question set)

This H5P content type is suitable for revision at the end of a unit. In fact, it is a group of slides where each of them can contain a different type of quiz question or activity. We used this Question set as a quiz MCU at the end of each unit. Employed were multiple-choice questions, fill the gap for code completion, drag the text for placing extracted code parts (text parts) in the to the right places and true/false questions.

2.1.4 Try, Alter and Execute (TAE) exercises

These exercises are meant to be supportive for students to see HTML (CSS, PHP) code, and have the possibility of directly experimenting with it. TAEs do not follow strictly ML philosophy we adopted, but the maximum limit for the length of MCU (less than 15 minutes) is met (Lindner, 2007). TAE exercises consist of two windows where the first shows a code and the second is used for code rendering after pressing the button "Run code".

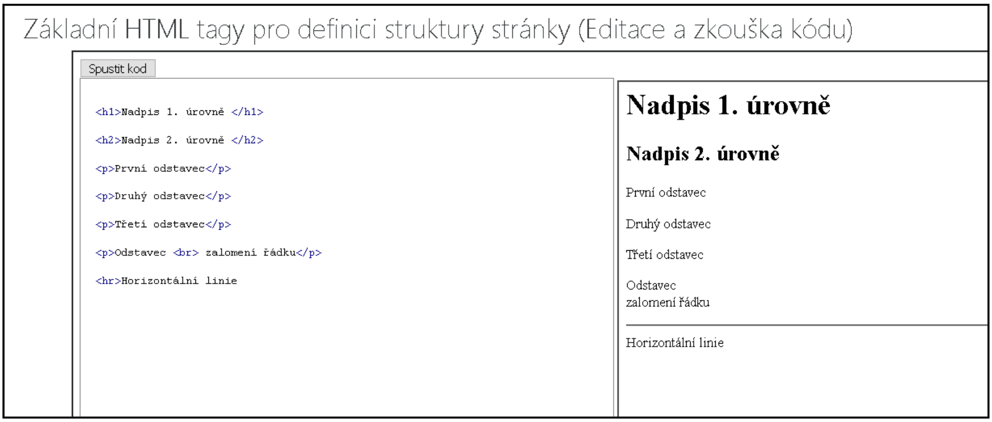

Figure 3. TAE exercise example, Headings, Paragraph and horizontal line in HTML

Source: Own work

TAE exercises have set task(s) that students should try and debug with a given code. Mostly they are focused on practicing/applying prepared code in a different context and after that, with Moodle Assignment they have to hand in their completed task to the teacher.

2.2 Creation and design of MicroLearning Units (MCU)

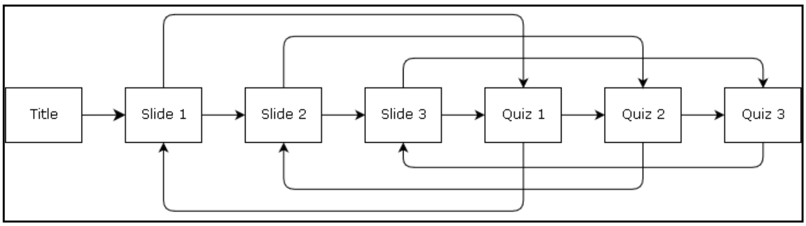

Figure 4. General model of a MCU with three content slides and three quiz slides

Source: Own work

Each MCU was created in similar design, just with adjustments according to above mentioned H5P content types (interactive videos, interactive course presentations, Question sets) used for their creation.

For purpose of planning and creating MCU, we always took a unit's content and from the beginning to end started to divide it by restraint of the number of possibly used terms for one MCU, but also taking into account logical groups within the given unit (e.g. keep HTML page structure tags within MCU). If the size of a logical group produced too long MCU, two were created instead. The possibility of connecting MCUs among each other would bring easier navigation for students. Unfortunately, LMS Moodle doesn't offer permalinks for activities, so for keeping all links valid even after exporting/importing of the course we didn't use links to interconnect them.

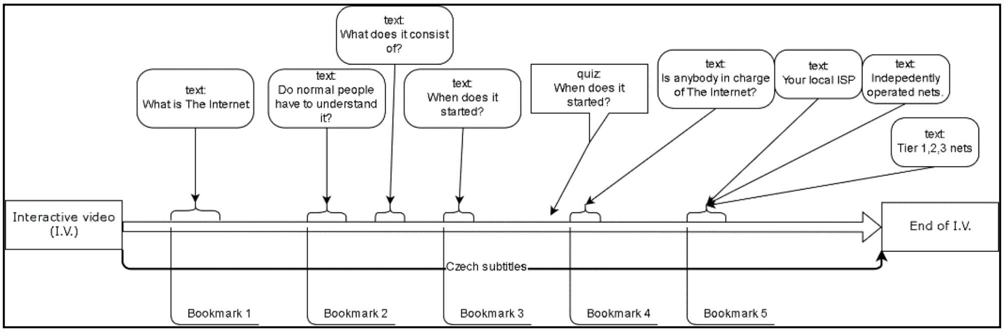

Figure 5. Example of added texts, quizzes in an interactive video
Source: Own work

Creating interactive videos was a bit different. The first and usually most important quality of a video that was searched for was its length in minutes. We set the limit to approx. 7 minutes for introductory videos and approx. 12 to 20 minutes for coding examples. Next were marked the main parts by Bookmarks and added labels where needed throughout a video. Lastly quiz questions were added and at the end a short quiz for revision.

2.2.1 Application of quiz questions within MCU

It's a matter of question where to place and how often to apply quiz questions for reinforcement within MCUs. Some findings show that post-instruction testing improves delayed retention learning (Haynie, 1994; Ramraje, 2011), so we employed a similar approach to the use of MCUs. Basically, one way is to use a quiz question immediately after presenting a piece of information, the second way is to postpone a quiz question after one, two or three other slides. Postponing a quiz question can roughly copy measures used against the effect of forgetting (forgetting curve) (Averell & Heathcote, 2011; Fisher & Radvansky, 2018) as used for instance in Anki application (apps.ankiweb.net). Another possibility was to apply a quiz question(s) at the end of MCU, which we mostly used.

Not to limit students in a way they are going to use quiz questions in MCUs we inserted links that are connecting "theoretical slides" with corresponding quiz questions at the end of MCU. Also, backlinks were set. Within interactive videos we weren't mostly inserting links as screen of videos is mostly occupied by text, graphics, text labels, test buttons and subtitles and yet another element could make it too chaotic. Even though videos can be set to stop and show a quiz question we usually made it voluntary to undergo in-video quiz questions not to interrupt viewers' experience.

CONCLUSION

The main reason for creating a new ML e-learning course was to offer to students (undergraduate IT teachers) a newer active way to study (for some) a not very interesting subject. For course creation, we chose the university's standard e-learning platform LMS Moodle with the use of H5P activities to add more needed interactive content forms.

The creation of a similarly founded ML course without the use of H5P would be possible but would limit interactivity and because of limited possibilities of interconnecting activities in LMS Moodle it would be also too fragmented and in the end, the course structure would be too complicated and disorganized. Also even though the environment of H5P is quite user-friendly, at least basic knowledge of HTML and its colours is needed, which restricts use of this tool to less IT skilled course creators.

From a general point of view, we see the benefits of ML (MCUs) that by creating small chunks, it offers a way for students to create their own study path and makes it easier for them to grasp particular parts of the whole. This is similar to the way we browse on the Internet and learn as we work – look up what is needed at a certain moment. Siemens (Siemens, 2007) sees knowledge in a distributed manner, the form similar also to the Web. This way we may connect ML with connectivism (Goldie, 2016). Important in this context is to carefully prepare the learning path by preparing MCU as step by step parts that self-contained though they are – they create students' mental image of a whole. The main course structure is still kept by LMS's course structure. This is different to the approach of the first ML system KnowledgePulse (Göschlberger & Bruck, 2017) or flashcards (Julie Phelps & Altabbakh, 2018) (that are also perceived as a kind of ML (Edge, Fitchett, Whitney, & Landay, 2012)) but focused on the particular micro-parts rather than on the whole. One of the negatives being mentioned in connection with ML is that it may lead to mere aggregation of isolated facts (Hug, 2012). By connecting LMS structure and logical division of subject matter (ideally interconnected in hypertext manner) we hope to address it.

Our approach to ML course is closer to the traditional e-learning course, which is a little bit different from many ML approaches of recent days (Jahnke et al., 2019). Because the creation of a new learning environment is time demanding and costly, we find the use of a classic LMS ~~as~~ the best way. By connecting the attractive form of the subject matter presentation with the possibility of testing code snippets (TAE) and creating new knowledge and skills directly within LMS, it opens the possibility for improvement of students' motivation and a higher rate of interest. Hopefully, also a higher rate of gained factual knowledge and learning satisfaction is met. TAE exercises are not totally novel as on the Web there can be found similar code testing sites. But incorporating TAEs into the course opens the possibility of studying, testing and developing coding knowledge and skills without the use of outside services that may stop operating, change service policy, etc. We also find it important that the use of a well-known LMS environment doesn't create new potential barriers for students to get used to it.

By creating a MCU with selected H5P modules we found out that there are almost unlimited possibilities in the approach to MCU design. Because of that, we created a basic model and limits that help create the MCU in the same way. At the same time because H5P modules offer a lot of feasible solutions we see possibility for further alterations and experiments. Even though the creation of a MCU is time demanding we see the benefit in the fact that the student is always tested (is given that possibility) after finishing even quite a small step. That gives the prospect of better-founded comprehension.

We intend to test the created course in comparison to the previously used one to find out if it helps students achieve higher score in factual knowledge or improves the approach to the subject matter and learning satisfaction. The topic could be further developed by creating TAE also for PHP hosted locally within the same web server as LMS. So far we solve PHP TAEs by using a third party online service. Finding a feasible way to interconnect various MCUs is a distant goal that deserves solving. Another possible way for development is better support for mobile devices as TAEs are unfortunately so far better when used rather on a computer. Further research can also focus on the issue of reinforcement quiz questions placement – if it is better to place them after each slide, delayed or at the end of the MCU.

ML is seen by many nowadays as a possible trend and we hope that making use of ML with an added value brings the prospect of improvements.

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AUTOMATION OF MATHEMATICAL KNOWLEDGE CONTROL WITHIN DYNAMIC MATHEMATICS PROGRAMS

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Abstract: *It has been established that there are computer tools (DMP – dynamic mathematics programs MathKit, GeoGebra, etc.), through which a computer-aided, but not formal check of mathematical knowledge is possible. The authors highlight the ways of automating mathematical knowledge control on the basis of DMP and discuss the experimentally proved hypothesis about the statistical equation of time required for the execution of geometrical tasks for construction, for research and for the geometric point of points. It has been established that for implementation of any form of control (traditional written or performed on the basis of DMP) the subjects of studying must allow the same amount of time. It has been proved that the form of control substantially affects the distribution of students by levels of educational achievements, in particular, statistically lower in the computer verification of knowledge based on DMP.*

Keywords: dynamic mathematics programs; e-learning; digital technology; control automation; mathematical knowledge.

INTRODUCTION

The spread of information technology to all sectors of the functioning of society has led to the emergence of computer tools to support the educational process. This contributed to the use of a package of office programs (texts, presentations, etc.), the attraction of specialized subject-oriented software, as well as the creation of computer programs for knowledge control. The last one, as a rule, is aimed at testing as a method of diagnosing educational achievements, which involves in most closed forms of response (one of many, several of many, establishing conformity, ordering, etc.). However, testing cannot always characterize the actual state of mastering the educational material. This is especially true of mathematics as a field of knowledge, for which the logic of reasoning is often more important, their validity and conciseness, rather than the answer.

From these positions testing as a form of mathematical knowledge control is not always effective, and therefore, computer tools are becoming more in demand which, on the one hand, simplifies the process of control for a teacher who has a sufficient level of formed digital competence, and on the other hand, they monitor the correctness of solving the tasks set.

1. ANALYSIS OF CURRENT RESEARCH

In line with the renewed recommendations of the European Parliament and the Council of the EU, digital competence includes a confident, critical and responsible use and engagement with digital technologies for learning, work and life in society and identified as one of the key to lifelong learning. (Council Recommendation, 2018). In addition, the significance of ICT technologies, digital competence is outlined in a number of regulatory documents, among them are: programs «UNESCO ICT competency framework for teachers» (UNESCO ICT competency, 2011), «European Framework for the Digital Competence of Educators» (DigCompEdu, 2017), etc.

The issue of computer control of knowledge is the subject matter of research carried out by a number of scholars. Thus, N. Morze and V. Vember have investigated the implementation of peer evaluation in the educational process (Morze, et al., 2019). V. Bykov and M. Shyshkina have discovered the possibilities of cloud-oriented technologies for evaluating the educational process (Bykov, et al., 2016). O. Kolhatin and L. Kolhatin have examined the quality of testing procedures and the interpretation of test results in the information and communication pedagogical environment (Kolhatin, et al., 2013). There are also studies on the control of mathematical knowledge, including through ICT, mathematical methods, etc. (Sontag, 2013; Bellman, 2016; B. Craven, 2012, etc.). These studies set out the theoretical and methodological foundations for controlling mathematical knowledge, outlining the historical origins of the formation of forms and methods of control in the study of mathematical disciplines.

We also consider the results of E. Smyrnova-Trybulska, who has substantiated the importance of digital technologies and e-learning in order to improve the quality of the educational process (Smyrnova-Trybulska, 2018). We consider fundamental in the context of the subject matter of our work the results of research which outlines the leading directions of application of information and communication technologies in the educational process (Bain, et al., 2010; Cardos, et al., 2009; Kostolanyova, 2013, etc.). We also find interesting the results of research on the use of dynamic mathematics programs in the educational process. Thus, Y. Zengina et al. demonstrated the effects of dynamic mathematics software GeoGebra on student achievement in trigonometry teaching (Zengina, et al., 2012). B. Güven et al. Presented a study on the effect of dynamic geometry software (DGS) Cabri 3D on student mathematics teachers' spatial skills was examined (Güven, et al., 2008). In the research by V. Mudaly et al. emphasis is placed on the fact that new methods of teaching mathematics are being sought with the purpose to improve teaching and learning while making mathematics relatable to the new generation of learners. In addition, the authors investigated effectiveness of the use of the GeoGebra app and found that it lies in allowing learners to successfully discover the properties of straight line graphs (Mudaly, et al., 2019).

The results of research confirm that computer testing does not always allow demonstrating the attitudes of a test taker, and fixes only the result of training. It has also been confirmed that the organization of qualitative control over academic achievements requires a considerable amount of time and, sometimes, the involvement of experts in the field of standardization, psychology, pedagogy in order to provide an adequate assessment based on tests, validity of tests, compliance with tests for age characteristics, etc.

The study of the peculiarities of the test control of academic achievements in the field of mathematics revealed the active use of computer testing programs in secondary education institutions. At the same time, scientists are not only updating the problem of developing test tasks, but also the need to create such computer tools, where it would be possible to follow the logic of reasoning by subjects of learning.

The analysis of the programmatic tools of the subject (mathematical) direction was revealed by the class of dynamic mathematics programs (DMP, which include MathKit, GeoGebra, Cabri, The Geometres SketchPad, Gran, etc.), which provides the possibility of studying / researching individual properties or numerical characteristics of mathematical objects based on the results of its direct operation (Semenikhina, et al., 2017). The request of educators to automate the control of mathematical knowledge led to the development of these programs in the direction of expanding their methodological tools. The latest versions of individual dynamic mathematics programs (DMP) have been replenished with additional computer tools, the use of which is not limited to simple testing, and at the same time can facilitate the organization of control over academic achievements precisely in the field of mathematics. These tools and ways of their use in the educational process are the subject of our study.

The aim of the study is to clarify the ways of automating mathematical knowledge control in dynamic mathematics programs and to analyse their effectiveness.

The aim led to the following tasks: 1) to substantiate the possibility of using DMP for automation of mathematical knowledge control; 2) to clarify the ways of using separate DMP for automation of mathematical knowledge control; 3) experimentally confirm the efficiency of the specified ways of using separate DMP for automating the mathematical knowledge control.

2. MATERIALS AND METHODS

A set of methods was used for solving the tasks: *theoretical* – the analysis of scientific and pedagogical sources and computer tools of the DMP to substantiate the possibility of their use for automation of mathematical knowledge control, generalization of methodological approaches and *modelling* of pedagogical situations for determining the ways of using DMP for the organization of control; *empirical – surveys, observation* of educational activities, pedagogical experiment to confirm the effectiveness of attracting PDM for automation of mathematical knowledge control; *statistical* – Student's average scoring criterion for comparing time spent on traditional and automated forms of control, and McNamara's criterion for determining the influence of the form of mathematical knowledge control on the distribution of learning outcomes.

The experimental base of the study became the Makarenko Sumy State Pedagogical University. Examination of test materials was carried out by leading teachers of the Borys Grinchenko Kyiv University.

The study was conducted in three stages. The first stage envisaged the study of scientific and methodological works of leading scientists in order to justify the possibility of using DMP for automating the mathematical knowledge control. The second stage was practice-oriented, since it required the acquisition of experience in working with DMP to determine the ways of using separate tools of DMP to automate the mathematical knowledge control. At this stage an examination of the tasks used during the pedagogical experiment to control academic achievements was conducted. The third stage was aimed at statistically confirming the effectiveness of attracting DMP for automation of mathematical knowledge control.

3. MAIN RESULTS

V. Proshkin and O. Semenikhina research results on the use of computer mathematical tools in the process of professional training of future mathematics teachers (Proshkin, et al., 2018) allowed determination of the theoretical basis of the use of information tools for controlling academic achievements, in particular the involvement of DMP for automation of mathematical knowledge control.

Our analysis of computer tools of DMP MathKit, GeoGebra (the programs selected as the most popular according to the survey of future teachers of mathematics and working teachers) made it possible to determine the ways of automating mathematical knowledge control, among which are:

1) direct verification of the integrity of the design;

2) step-by-step demonstration of the solution;

3) the use of special control tools (*Check Response* for automatically checking the answer through a pre-implemented solution algorithm, *Response Field* for open-form questions, a *Checkbox* for closed-form question answers (with one or more correct answers).

Statistical analysis of the results of the pedagogical experiment found that the form of control significantly affects the distribution of students by levels of academic achievement.

3.1. Discussion

Describe in more detail ways the process of automation of mathematical knowledge control on the basis of DMP and conducted pedagogical experiment.

1. Direct examination of the integrity of the design.

Using DMP it is possible to check the correctness of the construction through the interactive effect on the object – the change in the position of the elements on which the construction is constructed, should not affect the correctness of the reflection of the result.

Quite often, when constructing a mathematical model of a task, the subjects of study depend on the visual similarity of the geometric design, rather than the established rules of construction. In this case, even with minor changes in the position of the base objects the integrity of the structures is violated.

Example 1. Build a direct of Euler (GeoGebra, Figure 1).

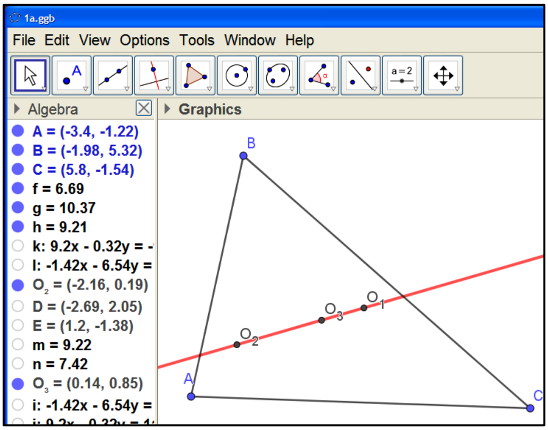

Figure 1, a. Correct construction
Source: Own work

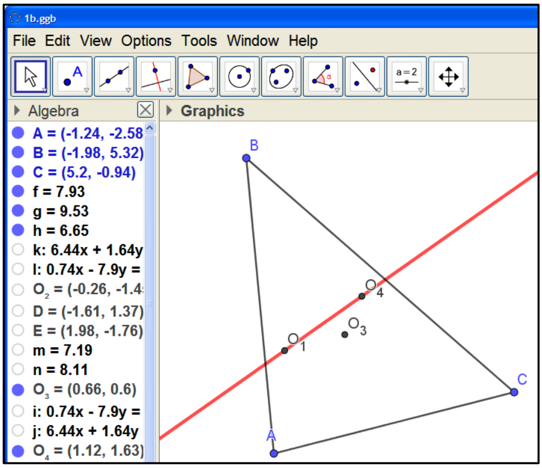

Figure 1, b. Incorrect construction
Source: Own work

Direct of Euler is a straight line on which there are three centres (centroid is a point O_1, orthocentre is a point O_2 and the centre of the circle described is a point O_3,) of any triangle.

The described method of control is fast, but is used as a rule when checking geometric tasks (tasks for construction, problems on the geometric point of points, problems on the construction of sections of polyhedra).

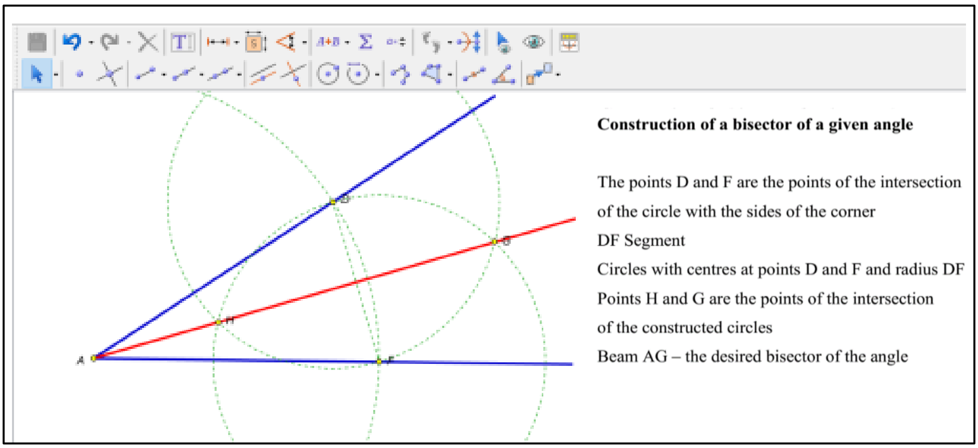

Figure 2, a. A step-by-step demonstration of constructing a bisector of a corner in MathKit
Source: Own work

2. Step-by-step demonstration of the solution.

DMP provides for a step-by-step demonstration of the solution. So, for MathKit, a turn-based demo is set by the *Show / Hide* and *Presentation* buttons (Figure 2, a).

You can also use buttons for *GeoGebra* for a step-by-step demonstration, but for this you need to write a script of the buttons in the Java language or go to the *Steps to build* or activate the *View / Protocol*, where the mode *Steps to build* is also active (Figure 2, b).

Example 2. Build a bisector of a given angle.

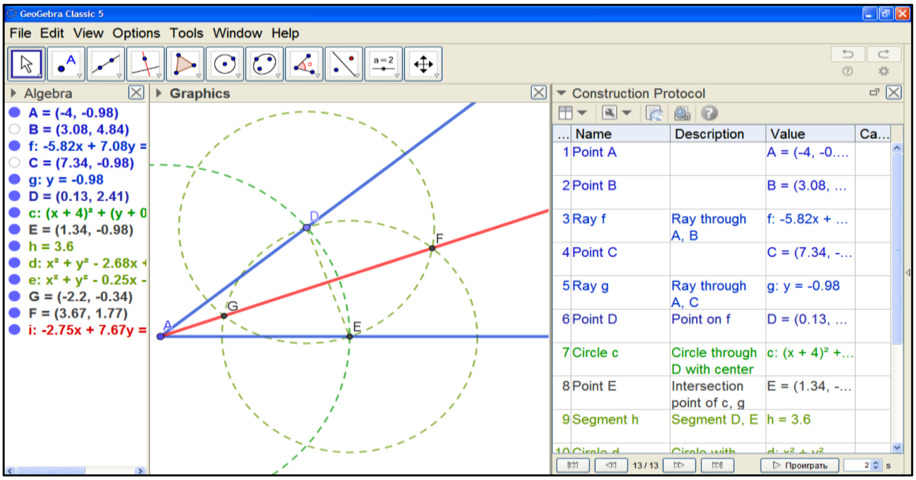

Figure 2, b. A step-by-step demonstration of building a bisector of a corner in GeoGebra

Source: Own work

In this way, we have the opportunity to check the logic of the subjects of the study in solving a mathematical problem, but we consider this form of control to be partially automated, since its use requires additional time expenditures to review each step of the solution and to analyse their correctness.

3. Use of special control tools.

The developers of the MathKit program offered *Checkbox, Response Field, Check Response*.

The *Checkbox* tool is intended to automate the test check of knowledge on a two-point scale "correctly-wrong". To use the Checkbox tool, you create fields where you can write the text of the terms of the task and place a mark-the choice of the correct answer.

To organize the checking of knowledge on the basis of checkboxes using the tool *Check Response*: if the options for the subject of the textbook fully coincide with the reference, the message is displayed on the correct answer.

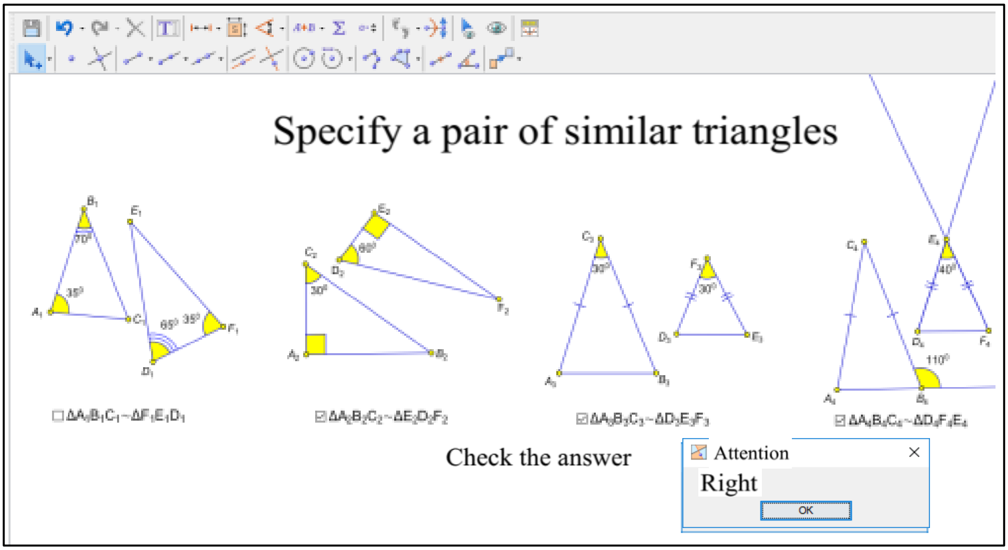

Figure 3. Specify a pair of similar triangles
Source: Own work

Example 3. Specify a pair of similar triangles (Figure 3).

Another tool – *Response Field,* allows you to create a reply box that is inputted from the keyboard. Such a tool is an analogue of the test with an open form of response. When using the tool to create a test task on the screen, a field for inputting a result and a window of properties of the button will appear at the same time, where instead of red text it is necessary to write the correct answer variants (by default their number is 3, and this number can be increased).

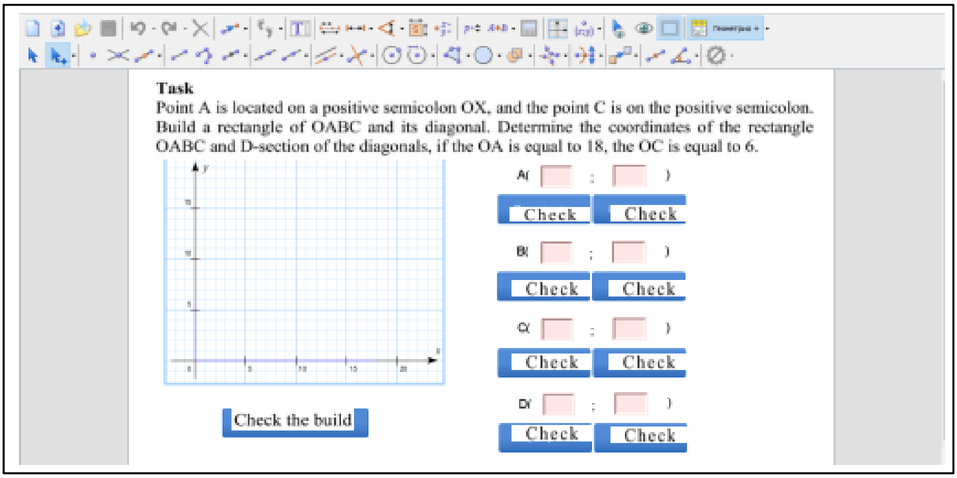

Figure 4. Organizing a response check at MathKit
Source: Own work

Example 4. Point A is located on the positive part of the abscissa, and the point C is located on the positive part of the ordinate axis. Build a rectangle *OABC* and its diagonals. Determine the coordinates of the vertices of the rectangle *OABC* and point D in the intersection of diagonals, if the length of the side of the OA is 18, and the length of the OC side is equal to 6.

Technically, the creation of such a type of task for the organization of control is not complicated, but requires careful consideration to take into account all possible options for entering the answer – the order of numbers, the format of numbers, the register of letters, the use of punctuation marks, etc. (Figure 4).

Using the *Check Response* software tool, MathKit allows you to automate the verification of the logic of reasoning when solving a mathematical problem, which is not provided in other software tools of mathematical direction. To organize automated control of mathematical knowledge, you need to build or calculate,
then select objects that are the answer to the task, and lock the *Check Response* button. After that, all intermediate builds and results are hidden, but only the condition remains and the button which was created. Note that the program developers have the ability to edit scripts using the buttons.

Teacher offering to solve a task in the program MathKit, which provides a button *Check Response*, can immediately check the correct answer and do not waste time understanding the method of solution, which may be not one.

Example 5. Build an angle of sinus equal to 3/5 (Figure 5).

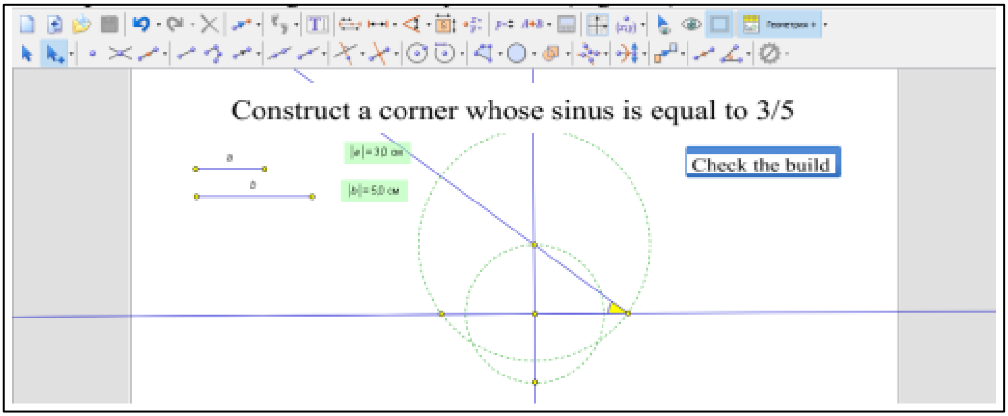

Figure 5. Automated validation of construction in MathKit
Source: Own work

The study of the tool confirmed its correct work under the condition that the object of verification is a point, line, segment, etc. (basic geometric object). For more details about the correctness of this tool we noted in our previous study (Semenikhina, 2014).

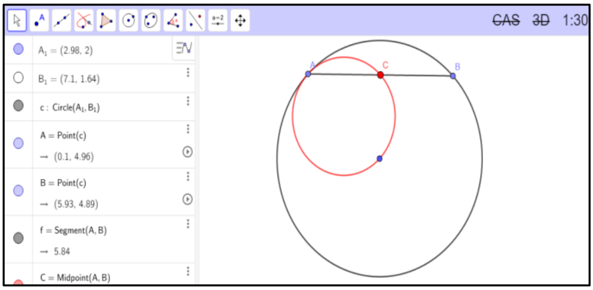

Figure 6. GeoGebra Exam Mode
Source: Own work

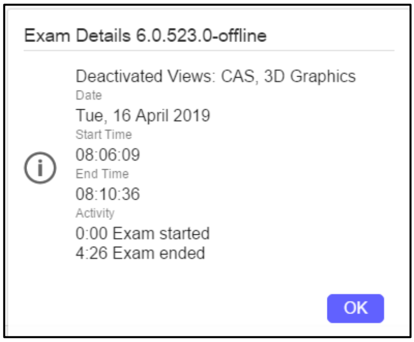

Figure 7. Journal of the task in GeoGebra Exam Mode
Source: Own work

In order to increase the independence *GeoGebra* developers provide *GeoGebra Exam* mode for restricting access to certain computer tools (selected by the teacher) and files hosted on a computer, as well as a ban on access to the Internet (Figure 6). The mode does not automatically control the learning achievements, but fixing actions in a special journal confirms / refutes the independence of the tasks. The log records: the date and time of the beginning of the task execution, the settings set, the exit from the full screen mode, if any, and the return to it, the time of the shutdown.

At the end of the exam, you can see the details of his passage in the journal (Figure 7) – the task is unlocked for 4.26 minutes.

The results of the study were subjected to statistical analysis. We examined the feasibility of using the described ways of automating control from two positions: the average score for comparing the time spent on traditional and automated forms of control (Student's criterion) and whether the chosen form of mathematical knowledge control on the distribution of learning outcomes influences (McNamara's criterion with the scale "Passed / Unpassed").

Describe the results below.

According to the same themes of the special course "Using a computer in teaching mathematics", evaluation of educational achievements was carried out in two different forms: the first provided for the usual solving of the tasks of the topic on the sheets without detailed explanations (Figure 8), the second is the use of DMP for automation of control without detailed explanation (Figure 9). The experts confirmed the identity of the test tasks and their compliance with the course work program, while it was confirmed that it was not possible in the first version to follow the logic of the considerations of those who were tested, unless the construction plan was required to be reproduced.

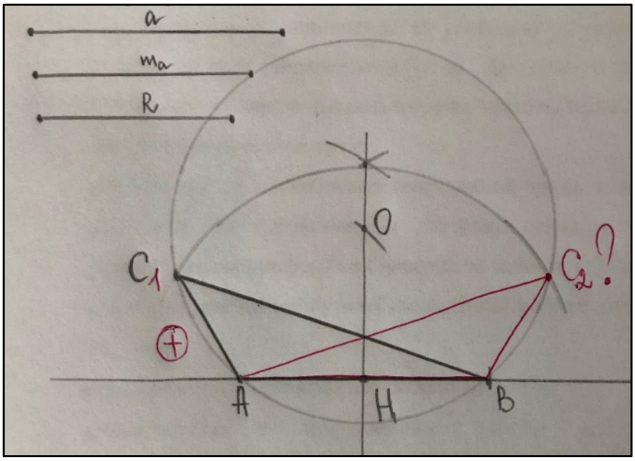

Figure 8. Task solving on paper without detailed explanations
Source: Own work

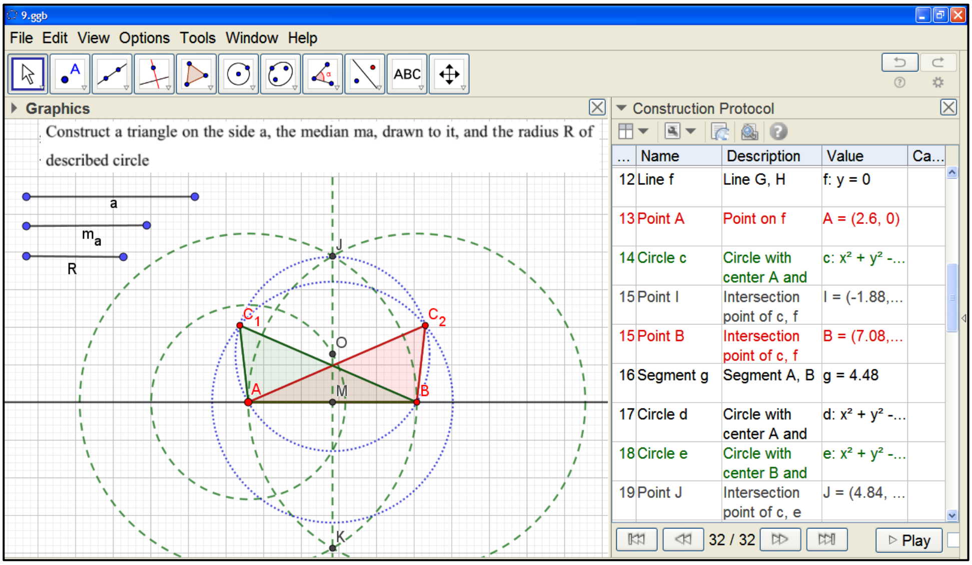

Figure 9. Using DMP to automate control without detailed explanation
Source: Own work

The average time for doing the tasks was studied (average Student's estimation method was used) and the number of persons who completed less than half of the tasks in each case (since the grade "Passed / Unpassed" involves two positions, the McNamara's criterion was used). The total number of respondents was 82.

Table 1.

Statistical processing of experimental results

Topic	AVG Runtime control works on paper	AVG Runtime tests using DMP
Tasks for construction	18.2 min	20.1 min
Tasks for research	20.3 min	17.6 min
Tasks on geometric place of point	15.3 min	13.9 min

Source: Own work

The hypothesis of statistical equality of averages (Student's criterion): accepted at the level of significance 0,05. The calculations confirm that the average time spent by students on the tasks is statistically the same ($T_{critical}$=1,97>$T_{empirical}$=1,29 for construction tasks, $T_{critical}$=1,97>$T_{empirical}$=1,56 for research tasks, $T_{critical}$=1,97>$T_{empirical}$=1,42 for tasks on geometric place of point).

At the same time, the analysis of the results in two forms of control revealed two facts:

1) verification of mathematical knowledge in the second form (using DMP) was faster;

2) verification of mathematical knowledge in the second form gave less number of successful assessments, which is statistically confirmed by the McNamara's criterion (Table 2.).

Table 2.

Statistical processing of experimental results

H_0: The form of control does not affect the distribution of academic achievements of students H_1: The distribution of students in terms of their academic achievement depends on the form of control	Double-sided McNamara's criterion for n>20 (n=B+C)

Topic	Written results	Results (DMP) Passed	Results (DMP) Unpassed	$T_{critical}$=3,84 $T_{experimental}$= =(b-c)^2/(b+c)
Tasks for construction	Passed	A=49	B=16	$T_{experimental}$=5,76> $T_{critical}$
	Unpassed	C=5	D=12	Accepted H_1

Tasks for research	Passed	A=47	B=15	$T_{experimental}$=3,86> $T_{critical}$
	Unpassed	C=6	D=14	Accepted H_1
Tasks on geometric place of point	Passed	A=42	B=18	$T_{experimental}$=6,54> $T_{critical}$
	Unpassed	C=4	D=18	Accepted H_1

Table 2 uses the notation: H_0 – zero hypothesis, H_1 – alternative hypothesis.

Source: Own work

This means that the form of control significantly affects the distribution of students by the levels of academic achievement – when performing written work, student success is higher, rather than in the computer verification of knowledge based on DMP.

CONCLUSIONS

The conducted research leads to the following conclusions.

1. According to the results of scientific research the possibility of using computer technologies in the organization of control has been substantiated. In particular,it has been found that there are computer tools that allow automated but not formal testing of mathematical knowledge. These tools include mathematics programs MathKit (or Mathematical Designer) and GeoGebra.
2. Among the ways of automating the mathematical knowledge control on the basis of the indicated DMP the following are defined: direct (interactive) verification of the integrity of the design; step-by-step demonstration (reproduction) solution; the use of special control tools such as Checkbox, Response Field, Check Response, and the use of special modes such as GeoGebraExam.
3. According to the results of the statistical analysis (Student's criterion), the hypothesis of the statistical equality of the time required for the execution of geometrical tasks for construction, for research and on geometric place of point. This means that any form of control (traditional writing or on the basis of the DMP) requires the subjects of the study to have the same amount of time for their implementation. At the same time (McNamara’s criterion), that the form of control substantially affects the distribution of students by the levels of academic achievement – when performing control works, the success of students varies. In particular, it is statistically lower in computer testing of knowledge based on DMP.

According to the results of the pedagogical experiment, we consider it expedient to introduce automated forms of control of mathematical knowledge based on the use of the programs MathKit and GeoGebra, without isolating at the same time some of the ways of its implementation.

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TOWARDS AUGMENTED REALITY EDUCATIONAL AUTHORING

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Abstract: *Nowadays, there is a growing interest in Augmented reality (AR) as a field of research, as well as a domain for developing a broad variety of applications. Since the coining of the phrase "Augmented reality" in 1990, the technology has come a long way from research laboratories and big international companies to suit the pockets of millions of users all over the world. AR's popularity among younger generations has inspired an effort to utilize AR as a tool for education. For teachers, starting with AR educational authoring, we selected some important milestones of the history of the field with the focus on the specific domain of educational applications. We comment on Videoplace and Construct3D projects in more detail. Finally, we draw a few implications from the available literature for educational authoring.*

Keywords: Augmented reality, taxonomy, authoring, digital cultural heritage.

INTRODUCTION

Augmented reality as an extension to GeoGebra (Brzezinski, 2018) presented an important milestone. We survey AR ideas in the context of the related field of virtual reality (VR) systems, which serve to enhance imagination, interaction and immersion. Our focus is educational authoring devices that exploit ideas from digital cultural heritage.

Myron Krueger named the new technology Artificial reality in the mid 70s, but Jaron Lanier's name Virtual reality won. In the year 2016, Dieter Schmalstieg and Tobias Holerer predicted that immersion would would not only be an important quality measure in VR systems, but in AR systems as well. Krueger*'s* Videoplace (1975) artistic goal was to establish a novel art of interaction. It projected silhouettes of users on the wall in real-time, where they interacted and despite the 2D nature of the simple virtual world they had a strong experience of "being there". The breathtaking educational goal of Videoplace was never reached. Myron Krueger presented fantastic 2D creatures to groups of children. They were expected to observe the artificial reality, name the unnamed objects, self-organize seminars to plan their further research, subdivide the workload and, eventually, discover for adults the new methods of research. The author assumed, that there are research methods which were not noticed by "adult science" and he relied on creativity of children… Videoplace visual artists had to create visible objects and their behaviours to be different from anything known. The Artificial reality mixed real and virtual to challenge imaginative, interactive and immersive discovery.

VR and AR are very close research fields and in spite of the clear delineation of the terms, it is sometimes hard for the public to distinguish between them. In the reality-virtuality continuum, defined by Milgram et al. in (Milgram et al., 1995) we can see that AR is a form of a broader mixed reality, which lies between entirely real and completely virtual environments. Azuma in his seminal paper (Azuma, 1997) defines AR as systems that have the following three characteristics:

1. they combine real and virtual,
2. they are interactive in real time,
3. they are registered in 3D.

In other words, this new medium uses real world surfaces for immediate projections, which are put into the same coordinate system. While Videoplace registered real user silhouette in the 2D virtual world of fantasy, AR computer vision subsystem registers the augmenting images into the 3D real world, and the user into 3D virtual one, which provides immediate imagination and immersion. We explain the difference in a more structured way in two AR classifications below.

When defining virtual reality, we have to enclose the 3rd and the 2nd point from the AR definition. Another important aspect of virtual reality is immersion in the virtual environment, but when defining the AR, we should use the term ultimate immersion because there is nothing more immersive than the reality itself.

Despite the differences, these two fields have a connected history. For example, Sutherland's Ultimate display (Sutherland, 1965) or head-mounted display (Sutherland, 1968) are important milestones in both AR and VR history. The term virtual reality has been used to describe different things, for example a theatre, but in the '80s, the term virtual reality was coined and popularized by Jaron Lanier (as referring to immersive environments created by applications with visual and 3D effects, Lanier, 2010) and the boom started at the beginning of the '90s. Not long after, the phrase augmented reality was coined by Tom Caudell in 1990 (Caudell and Mizell, 1992) and the boom started with the beginning of the new century. We describe a chronologic selection of 20 VR/AR milestones (ideas, papers, projects, books) in Part 1 and AR systems in general in Part 2. Part 3 compares two classifications to cover the AR field more generally. Finally, we identify the potential in AR authoring methodology. We discuss the implications and apply our approach to the Construct3D project in Part 4.

1 SELECTED MILESTONES (1966-2016)

In view of the possibility that any chronological selection remains arguable, we identified the following "minimal set" of 21 cited findings in the first 50 years of VR/AR. This evolution resulted in a relatively general AR system, which we present in Part 2. Analogously with computer graphics reference model, it can serve to specify the particular architecture and application functionality. The variety of options can be found in two prominent textbooks (Bimber and Raskar, 2005), (Schmalstieg and Höllerer, 2016). To reduce the reductionism risk, we describe the classifications of technical alternatives in Part 3. Besides important landmarks, we included several famous items, which influenced world VR/AR popularity in given time. In Part 5, we will explain data streams in one session with the "classic" educational application, Construct 3D. Adding a new chapter to the three already submitted (Prodromou 2019), we explore AR ideas in the context of the related field of VR systems. They discuss AR mathematics teaching and its qualitative evaluation (Babinska, Dillingerova, and Korenova, 2019), rich hardware options (Bohdal, 2019), and adequate didactic evaluation (Kostrub and Ostradicky, 2019). All these aspects should be taken into account by an author of a novel AR educational project.

1966 Ivan Sutherland presented his concept of the ultimate display. His idea, however, goes beyond the limits of VR and AR that we know today. In his paper (Sutherland, 1965), he remarked that: "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal". This device is considered the first AR interface. In 1968, Sutherland presented his popular head-mounted display (Sutherland, 1968).

1975 Myron Krueger experimented with computer generated art and interaction. In the Videoplace project, a computer responded to gestures and interpreted them into actions. The audience could interact with their own silhouettes generated from the video camera (Krueger et al., 1985).

1978 Professor Steve Mann is wearing the HMD (or HUD) since 1978. In 2001 Peter Lynch shot about him the film called Cyberman. Much of the film was created by Mann himself with his EyeTap (Mann, 2004). EyeTap is the HUD (heads-up display mounted in glasses), which records the reality with the camera, creates an virtual information and merges the reality seen by the user with a virtual information using a beam splitter. (Again, there are multiple meanings of HMD or HUD.)

1990 Tom Caudell, the researcher who developed the AR system supporting the aircraft manufacturing in the Boeing factory (Caudell and Mizell, 1992), coined the phrase augmented reality.

1991 The concept of "ubiquitous computing" was presented by Weiser (Weiser, 1991) in the beginning of the ’90s. The goal of "ubiquitous computing" is to provide computer interfaces that are natural for the users, to develop the computers which are not visible but "omnipresent" in everyday life. This concept is closely connected to the possibilities and techniques of the AR and the fusion of the fields is known as the ubiquitous AR. (In the year 2016, Schmalstieg and Höllerer proposed Weiser-Milgram spectrum of AR options).

1993 The CAVE: Audio Visual Experience Automatic Virtual Environment was presented to the public. CAVE contributed to public awareness of VR.

1993 Steven Feiner, Blair MacIntyre, et al. published two major AR papers. The first paper (Feiner et al., 1993b) presents the KARMA (knowledge based AR for maintenance assistance) system which uses the optical see through head-mounted display that "explains simple end-user laser printer maintenance". The second paper (Feiner et al., 1993a), presents 2D information windows in the AR, a technique, which is nowadays broadly used in smartphone (pseudo) AR systems.

1997 Ronald T. Azuma published the first survey (Azuma, 1997) on AR. He gave the definition of augmented reality, which is considered the most relevant. Also, he listed the biggest problems of AR as the registration and the sensing errors. The paper presents a broad survey of different applications of AR in medical, manufacturing, visualization, path planning, entertainment and military fields.

1999 ARToolkit was developed by H. Kato in the Nara Institute of Science and Technology. In 1999 Kato and Billinghurst published their paper (Kato and Billinghurst, 1999) about using HMD and markers for the conferencing system, based on the method proposed by Rekimoto (Rekimoto, 1996). ARToolkit is a computer library for the tracking of the visual markers and their registration in the camera space (http://www.hitl.washington.edu/artoolkit/). With the ARToolkit one can easily develop AR applications with virtual models assigned to different markers. For an example see Figure 4.

2000 Hannes Kaufmann, Dieter Schmalstieg and Michael Wagner introduced Construct3D, a three- dimensional geometric construction tool based on the collaborative AR system ‘Studierstube’. The setup uses a stereoscopic head mounted display (HMD) and the Personal Interaction Panel (PIP) - a two-handed 3D interaction tool that simplifies 3D model interaction. Applications in mathematics and geometry education at the high school and university levels were discussed.

2002 Bruce Tomas developed the first AR outdoor game called ARQuake (Thomas et al., 2000). It was an AR version of the computer game Quake. Different versions of the system (2000– 2002) used the optical see through head-mounted display, mobile computer stored in the backpack, haptic gun or handheld device with button, head tracker, digital compass, GPS system and/or markers. It allowed the user to walk around in the real world and shoot virtual enemies from the Quake game.

2005 Oliver Bimber and Ramesh Raskar published the first book on Spatial Augmented Reality (Bimber and Raskar, 2005). They describe and categorize AR systems into 3 categories: head-mounted, handheld, and spatial, and then focus on the spatial systems. The main difference between spatial AR and other categories is that in SAR the display is separated from the users of the system and so is suitable for bigger groups of users. SAR systems usually consist of digital projectors, which display graphical information directly onto physical objects. Bimber and Raskar describe the technique of calibration of several projectors, which compensate the inequality and the colour of the surface.

2007 Klein and Murray in their paper (Klein and Murray, 2007) proposed a method for a markerless tracking for small-workspace AR applications. They track a calibrated handheld camera in a previously unknown scene without any known objects or initialization target, while building a map of this environment.

2009 Although the spatial AR (and the projection mapping techniques) was introduced several years before, the biggest boom in the urban projection mapping was in 2009-2010. As the most famous examples we have to mention the projection mapping during the 600th anniversary of Orloj — the astronomical tower clock situated at Old Town Square in Prague — in 2010 (the macula, 2010), or 2009–2011 NuFormer Projections in the Netherlands (NuFormer, 2011).

2010 When Microsoft released Kinect, the motion sensing input device for the Xbox 360 console, it was expected to be "the birth of the next generation of home entertainment" (Takahashi, 2009) but not a milestone in the AR history. The Kinect sensor developed by PrimeSense company became a really cheap ($150) source for the depth information for AR applications, i.e. how far is the real object in the scene. The sensor itself consists of the rgb camera, the infrared projector which projects a pattern of dots and the detector which establishes the parallax shift of the dot pattern for each pixel. Instead of (x,y) we have (x,y,z) measurement of scene geometry. Kinect holds the Guinness World Record of being the "fastest selling consumer electronics device" (8 million units in its first 60 days). When the first hackers broke into the device and found the way how to control the sensors it took only 2 months and hundreds of AR application using Kinect sensor appeared on the Internet. For the top examples see 12 best Kinect hacks (Vsauce, 2010).

2011 Qualcomm presented Vuforia — the software development platform for AR. Vuforia enables the usage of real-world image markers and development of native applications with support for iOS, Android, and Unity 3D (Qualcomm, 2013).

2016 Pokemon GO, an AR game developed by Niantic for iOS and Android devices, was released in summer 2016. The game became massively popular and had been downloaded more than 500 million times worldwide by the end of the year 2016.

2016 Microsoft Hololens headset launched for developers. In was the first AR head mounted display to hit the market in 2016.

2016 Dieter Schmalstieg and Tobias Höllerer published the important textbook *Augmented reality: Principles and practice* (Schmalstieg and Höllerer, 2016). The detailed presentations are available for free download and correct academic use from http://www.augmentedrealitybook.org.

2. AR SYSTEMS

There is a discussion in the AR community whether the definition created in the 90s still suffices the requirements of the users. Especially in the commercial sphere there exist many applications which are categorized as AR applications, but do not fulfil the second or third of Azuma's rules. These applications usually lie within the reality-virtuality continuum, but cannot be considered AR. This lack of true commercial AR leads to misclassification also in some scientific publications.

For example, in the extensive survey (Olsson and Salo, 2011) published in the proceedings of ISMAR authors decided to include 2 kinds of applications: AR browsers which they defined as: "...usually includes the delivery of points of interest (POI), user-created annotations, or graphics based on the GPS location of the device and orientation of the built-in magnetometer" and image-recognition-based AR which was defined as: "based on connecting surrounding objects, products, and other physical targets with digital information with the help of visual recognition. By identifying quick response (QR) codes, bar-codes, other graphic markers, or the objects themselves..." Here, we strictly follow Azuma's definition and we decided to call the systems not fulfilling these rules the pseudo-AR ones.

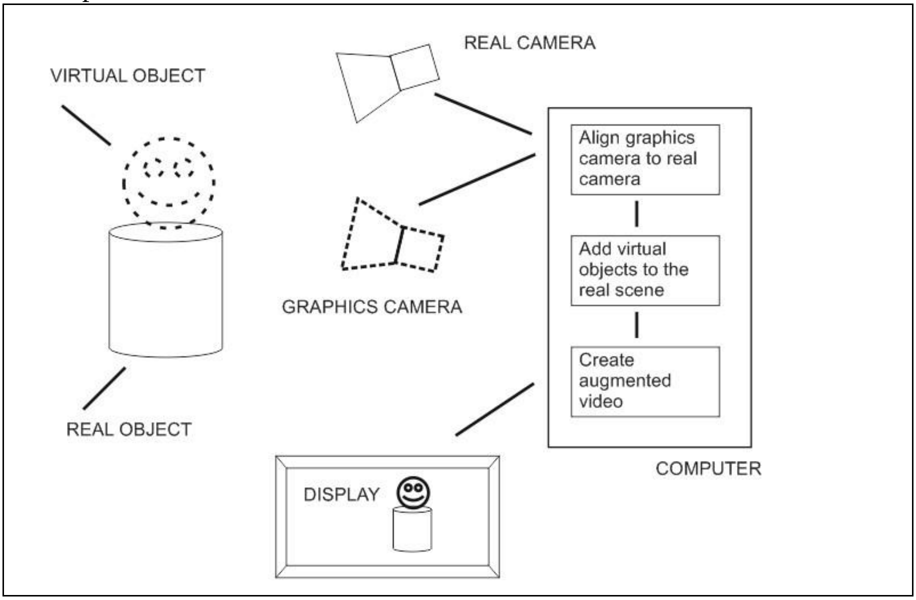

Figure 1. A scheme of AR system
Source: Own work

AR systems can consist of many different elements, depending on the type of the application. We can divide these elements into four categories: *inputs (sensors)*, *outputs (projectors, displays)*, *computers* and *accessories*. It is necessary for every AR system to have at least one sensor for the estimation of the user's position (camera, GPS receiver), one device to display the AR or to add virtual objects into user's view frustum (display, projector) and some device capable of processing data (computer). All the different components, elements, subsystems, necessary for the AR system can be incorporated in one device, for example a smartphone, tablet or notebook with a built-in webcamera. Many types are explained in (Bimber and Raskar, 2005), (Schmalstieg and Höllerer, 2016).

In Figure 1, we can see the scheme of the common AR system equipped with a camera, a computer and a display. As the first step, the position of the real camera in space has to be estimated and the alignment (registration) of the real camera to the graphics camera has to be done. Visual (or other types of) markers, pattern matching or local features matching are usually used for the estimation of the rotation and translation of the camera to the object to be augmented (we will focus on the registration of the virtual and real camera in the next section). The virtual objects are then merged with the real scene and the augmented video is created and displayed.

3. TWO CLASSIFICATIONS OF AR APPROACHES

The AR systems can be categorized by different factors, including the application area, the possibility of more people collaborating or the size of the full system. In the following section we present two different classification schemes of the AR applications. The first one was developed by Bimber and Raskar in (Bimber and Raskar, 2005) and it presents a device-based categorization (3.1). The second scheme is our own classification based on the way of augmentation of virtual and real world. The user's immersion is the key aspect of the AR systems. Our classification (3.2) is inspired by the survey from Azuma (Azuma, 1997) and it can be helpful in taking project decisions.

3.1 Device based classification

The categories proposed in (Bimber and Raskar, 2005) are based on how the output device is connected with the user. If the user wears the device on his head, we talk about head-mounted devices. The systems designed to be carried in hand belong to the handheld category and stationary systems not carried by the user are the spatial category.

3.1.1 Head-mounted devices

The head-mounted category consists of five main types of devices: Optical see-through HMD, Video see-through HMD, HMProjectors, HMProjective display and retinal displays. For more information about HMDs see (Cakmakci and Rolland, 2006).

Optical see-through head-mounted display Azuma (1997) states that: "Optical see-through HMDs work by placing optical combiners in front of the user's eyes. These combiners are partially transmissive, so that the user can look directly through them to see the real world. The combiners are also partially reflective, so that the user sees virtual images bounced off the combiners from head-mounted monitors. The optical combiners usually reduce the amount of light that the user sees from the real world. Since the combiners act like half-silvered mirrors, they only let in some of the light from the real world, so that they can reflect some of the light from the monitors into the user's eyes."

Video see-through head-mounted display. This type of HMD was defined (Azuma, 1997) as: "Video see-through HMDs work by combining a closed-view HMD with one or two head-mounted video cameras. The video cameras provide the user's view of the real world. Video from these cameras is combined with the graphic images created by the scene generator, blending the real and virtual. The result is sent to the monitors in front of the user's eyes in the closed-view HMD."

Head-mounted projectors beam the generated images onto the ceiling and use two half-silvered mirrors to integrate the projected stereo image in front of the user.

Head-mounted projective displays redirect the image created by miniature projectors with mirror beam combiners so the images are beamed onto retro-reflective surfaces in front of the users eyes.

Retinal displays use low-power semiconductor lasers to project modulated light directly onto the retina of human eye. The main disadvantage of this technique is that it provides only a non-stereoscopic monochromatic image (Bimber and Raskar, 2005).

3.1.2 Handheld devices

Handheld devices are nowadays the most popular platforms for the AR applications. These devices usually incorporate all the necessary sensors, computer and display (or projector) in one portable gadget. Common handheld devices are smartphones, tablets, palmtops or notebooks. Although most of the published papers in the area of mobile AR focus on these particular devices, there were also some efforts to build special handheld devices, for example iLamps (Raskar et al., 2005). In iLamps Raskar et al. presented object augmentation with a handheld projector utilizing a new technique for adaptive projection on non-planar surfaces using conformal texture mapping.

3.1.3 Spatial devices

The spatial category encloses different solutions designed to be fixed within the environment (not to be worn in the hand or on the head). An example of spatial solutions are: PC stations with a webcamera, the CAVE (cave automatic virtual environment) (Cruz-Neira et al., 1993), Projection mappings (the macula, 2010; NuFormer, 2011), Virtual showcase (Bimber et al., 2001). The Fish tank is the title of a system consisting of a computer station equipped with a webcamera and a monitor which are used for AR at home. The CAVE is an immersive virtual reality/scientific visualization system, which lies between VR and AR. The CAVE is a room-sized cube where three to six of the walls are used as projection screens.

The Virtual Showcase developed by Bimber et al. (Bimber et al., 2001) presents a projection-based multiviewer AR display device which consists of half silvered mirrors and the graphical display. In this device the user can see real objects inside the showcase (through the half-silvered mirrors) merged with virtual objects or layers displayed on the projection screen under the showcase. This technique makes use of the concept of Pepper’s ghost developed in 1862 (Burns, 2010).

3.2 Perception-of-reality-based classification

In our classification we start from Azuma’s work (Azuma, 1997) and we divide AR systems based on the way they create the augmented experience. The first category includes applications which create AR by adding the virtual information (3D models, images, text) to the record of reality. The second category includes systems which create AR by displaying/projecting virtual information directly in front of our vision of reality. Table 1 relates the device-based classification and perception-of-reality-based classification.

3.2.1 The record of reality mixed with virtual information (added to record)

All of the video see-through approaches belong to this category. The video see-through device basically consists of the camera which records the reality and the display (or a projector with a projection screen) which provides the user with the reality mixed with the virtual information (the augmented experience). This category includes video see-through head-mounted displays, most existing handheld devices (smartphones, tablets, palmtops, netbooks) and the Fish tank solutions.

3.2.2 Reality mixed with virtual information (added to reality)

This category includes all the applications in which the virtual information is projected directly on the real world objects, or onto the optical see-through device. The typical representatives of these approaches are the projection mapping applications, for example, the projection on the astronomical tower clock Orloj situated in the centre of Prague (the macula, 2010). Other systems which belong to this category are optical see-through head-mounted displays, retinal displays, head-mounted projectors, head-mounted projective displays, CAVE (Cruz-Neira et al., 1993), Virtual showcase (Bimber et al., 2001), and also some handheld solutions (for example, iLamps (Raskar et al., 2005), as described in the section 4.1.2).

The morphological Table 1 offers for AR systems a two-dimensional orientation, which can be helpful both for study and authoring. In fact, any AR system was built following such a project decision. The classification is open. We can add a next row for retinal display, for example.

Figure 2 illustrates some general AR building blocks (Bimber and Raskar, 2005) in 3 layers. We added selected user responses above. Tracking and registration, display technology and rendering represent fundamental components (subsystems). "On top of this base level, three more advanced modules can be found: interaction devices and techniques, presentation, and authoring... Ideas and early implementations of presentation techniques, authoring tools, and interaction devices/techniques for AR applications are just emerging", wrote the authors in 2005. "Some of them are derived from the existing counterparts in related areas such as VR, multimedia, or digital storytelling. Others are new and adapted more to the problem domain of AR. However, it is yet too early to spot matured concepts and philosophies at this level". "The third layer, the application, is finally the interface to the user. Using AR, our overall goal is to implement applications that are tools, which allow us to solve problems more effectively. Consequently, AR is no more than a human-computer interface which has the potential to be more efficient for some applications than others." In other words, there are 2 phases of communication: authoring and presentation.

Table 1

Relating the device based classification and perception of the reality based classification.

	added to record	added to reality
head-mounted	video see-through HMD (Museum wearable (Sparacino, 2002))	optical see-through HMD (Sutherland's HMD (Sutherland, 1968))
handheld	mobile/tablet AR (e.g. museum guides (Bruns et al., 2007; Miyashita et al., 2008), (Kusunoki et al., 2002; Bay et al., 2006; Föckler *et al.*, 2005))	optical see-through handheld displays handheld projections (iLamps (Raskar et al., 2005))
spatial	fish tank mirror projections (Kalman, 1960).	Pepper's ghost (Adrien and Claire, 2013) projection mappings (the macula, 2010) holographic displays (Bimber et al., 2006)

Source: Own work

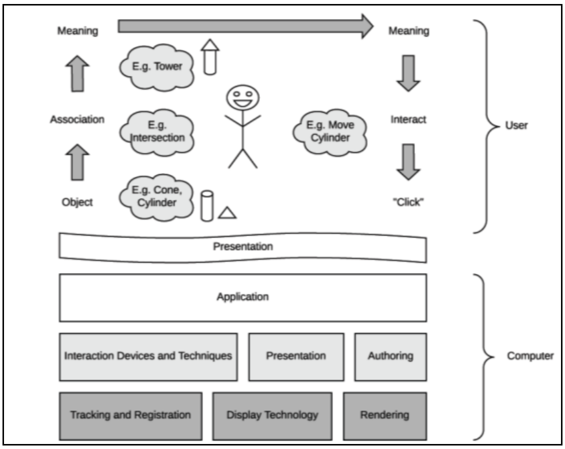

Figure 2. The AR building blocks and an example of user responses, recognizing objects, generating associations, fixing meaning, and interacting eventually.
Source: Own work based on Bimber and Raskar, 2005

About a decade later, there is a brief Chapter 10 Authoring in (Schmalstieg and Höllerer, 2016, pp. 329-344): "Based on a definition of setup for input and output, the authoring defines a story (application logic), driven by interaction and influencing actors arranged on stages". Multimedia objects are named actors here, the story can be described as a state machine, and game is not taken into account. The shift from single word authoring in the first AR book to a separate chapter in the second prominent AR textbook can be extrapolated to a vision of an universal AR authoring tool and workflow, like PowerPoint for a wide public, Movio for a virtual heritage community... Moreover, "AR has the potential to become the leading user interface metaphor for situated computing... The world becomes the user interface... (Schmalstieg and Höllerer, 2016)" The authoring, teaching, and learning can be everywhere, any time. How to solve the authoring problem more effectively? The AR literature does not offer either an universal authoring tool, or the methodology. Therefore we propose to apply the novel theoretical framework introduced in *Theorizing digital cultural heritage* (Cameron and Kenderdine, 2010). In other words, VR evaluation is more matured than AR one. We are going to explain this with the Construct3D example.

4. AUTHORINGIMPLICATIONS

Combining parts of real and virtual worlds, human communication organizes the content using stories and games (monologue, dialogue). A "Virtual Museum" can be defined as a multimedia semiotic system, which offers a set of microstories or game moves to communicate the given message, main story, part of metastory. Virtual museums present multimedia collections for visualization, activization, and even hermeneutics (presenting invisible). A recent prognosis is given in (Papagiannakis, 2018) "Storytelling, presence, and gamification are three basic fields that need to be taken into account when developing novel mixed reality applications for cultural heritage...".

How should one measure virtual museum quality? The key human experience with stories and games is a depth of immersion, which has five levels: curiosity, sympathy, identification, empathy, transportation (Glassner, 2009). The strongest form of gameplay immersion is flow experience (Csikszentmihalyi), “the sense that the outer world has fallen away” (Glassner, 2009). The question is how to measure a quality of story/game immersion. The general answer lies in the level of interestingness. In particular, the quality measurement can be obtained using quantitative, qualitative, and virtual museum engagement factor (Sherwood) measurements (Visits/visitors*duration) after (Cameron and Kenderdine, 2010). The time of engagement is proportional to the level of interestingness. E.g. the winning MOOC seems to be the world-famous Coursera hit Learning How To Learn, with over 3 million subjects, who were engaged for 12 recommended hours (https://www.coursera.org/learn/learning-how-to-learn).

The specific quality measure for education with AR is proposed by (Kostrub and Ostradicky, 2018). According to SAMR (Puentadura, 2018), there are four levels of technology contribution in the classroom: Substitution, Augmentation, Modification, and Redefinition. These SAMR model levels proposed by Puentadura can be compared against classical Bloom's taxonomy of educational goals. For example, "redefinition" (Computer technology allows new tasks that were previously inconceivable) can be seen as Evaluating and/or Creating level as defined by Bloom.

The user can recognize visual percepts with growing complexity: single pixel, output primitive, graphical object, semiotic representation, pattern, metaphor and even an enthymeme. Enthymeme experience changes the user into the co-author, the student into an cooperating (self-)teacher. This sharing of untold, "the body of proof", "the strongest of rhetorical proofs..." can be exemplified with classical syllogism "Socrates is mortal because he's human", where one of premises is not stated (All humans are mortal. Socrates is human. Therefore, Socrates is mortal.) In virtual museology (Cameron and Kenderdine, 2010) the enthymeme means a top achievement, presenting unpresented, visualising invisible. These museologic enthymemes are not reduced to rhetoric only, they consist of multimedia objects (actors in AR system).

We learn in three ways only: 1. by pain, via amygdala, no repetitions, 2. by repeating, via thalamus, 3. by discovery, enjoying endorphins, expressing AH, AHA or HAHA (Koestler, 1964). The third way activates multiple brain parts in a symphony of reconnections (Aamodt, 2009), A. Koestler calls this bisociation. These two observations led us to define local interestingness.

Painful learning tradition was stopped by Comenius. Repetitive learning tradition prevails today, motivated not by internal interestingness, but by external needs. The third one, learning by discovery, is interesting itself, pleasant and funny. Using this opinion, we can comment on AR educational authoring, as well.

Arthur Koestler discovered this a posteriori definition of interestingness, which we use as a technique of making any text or image sequence locally interesting. What was interesting, causes the AH, AHA or HAHA reaction in three areas of human creativity Art, Science, and Humour (ASH). We live to escape from the banal associative mental life to maximize our cultural capital with bisociations, the acts of creation at the side of an author and, hopefully, at the side of the reader or virtual museum visitor. If we are not sure with AHA, we are halfway, expressing audible HM... How to reach HM? Ask a question, use rhetoric.

The global interestingness of any story/game is given by its theme (Rizvic, 2013). The local interestingness can be authored or evaluated by the bisociations, causing AHA reactions. The engagement can be improved by a set of rhetorical devices (e.g., pause, question, metaphor, intonation, repetition, and even an entymeme), gamification, funology (from usability to enjoyment) (Blythe, 2004). Good presentation ideas improve local interestingness of given communication. While rhetoric organizes oral presentation, AR application can profit from these well-working attention-getting tricks using sets of mutimedia objects, as well. For example, very inspiring metaphors for explaining algorithms can be found in (Forisek and Steinova, 2013). The HAHA reactions were measured and even classified by Huron (Huron, 2004).

The virtual visitors enrich and train their multiple intelligences (after Gardner) and they are expected to achieve various educational goals (within Bloom's taxonomy) with given level of attention. We understand educational AR authoring as a specific subsystem of virtual museum in a wide sense, e.g. educational content with GeoGebra YouTube Channel is a specific educational virtual museum or exhibition. AR may serve as an ubiquitous or standalone subsystem within any educational unit, story, or serious game. Using this approach, one can author or even evaluate the AR system effects. Let us apply the proposed approach to comment on Construct3D demo.

4.1 Classical project Construct3D on Youtube in 90 seconds overview

The far-reaching educational goal of Videoplace was a sort of visionary dream. The successful practical project appeared decades later, it was Construct3D (Kaufmann et al., 2000), which has been the most cited project in the field of mathematics education using VR. What is the theme of Construct3D?

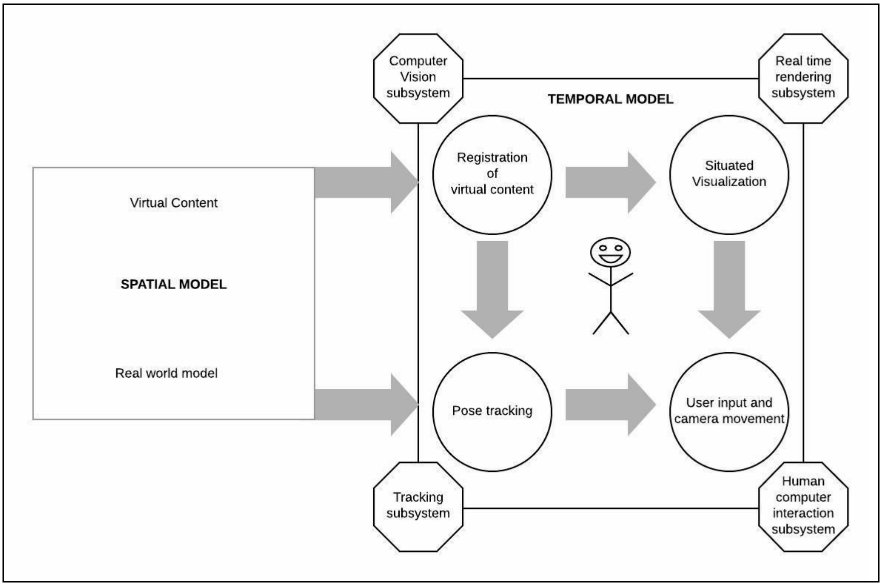

Figure 3. Spatial and temporal modelling of Construct3D session
Source: Own work based on Schmalstieg and Höllerer, 2016

"Spatial abilities present an important component of human intelligence. The term spatial abilities includes five components, spatial perception, spatial visualization, mental rotations, spatial relations and spatial orientation... Generally, the main goal of geometry education is to enhance special abilities by training spatial skills. As shown in various studies... spatial abilities can be improved by virtual reality (VR) technology." For any given task, it is possible to make the geometric solution visible for the teacher, but not for students. The theme means the global interestingness.

Construct3D offers both visualization and activization of students. This can be demonstrated by a 90-second YouTube video named Construct3D – Overview (Kaufmann, 2009). The real and virtual spaces are merged, augmented with an interactive PIP (Personal Interaction Panel) and 3D geometric objects (cone, cylinder, globe, and annotated coordinate axes). The user experience serves immersing collaborating students to improve their imagination, interaction, and spatial skills. There are local interestingness devices like real-time feedback or indicating the top of cone by a red marker, however, the closing part of the video offers a new level of local interestingness – two views from two viewpoints in a single screen. This trick destroys the illusion of single view and moves us to another virtual space, where we can compare. The comparison leaves the field of associations to bridge over two contexts, to bisociate, and, if one is fortunate enough, this results in an AHA, AH or HAHA moment (Koestler). This possible effect may bring a bit of the personal discovery for an activated student, and even result in seeing the invisible, a percept not directly presented by AR system.

Construct3D is implemented using StudierStube. The data flows are indicated in Figure 3, which we adapted after (Schmalstieg and Höllerer, 2016).

What are the properties of geometric objects in this setup? They are inspired by real world, physical universe, but they have to be modelled in mathematics. This means that they consist from infinite number of points. This number must be reduced for computer representation, typically using textured triangles. In final implementation are these AR actors stored with given precision. The four universes of computational mathematics (world, model, representation, implementation) offer a basis for visualization (pixels, triangles, objects, iconic and symbolic representations, metaphors...). However, some parts of virtual and real scene should serve for augmenting and interaction. Such real-time actions require careful optimizations [Lack19], especially for AR mobile applications, where the computational power is limited.

4.2 AR workshop for kids

The first scientific exhibition for the general public in Slovakia, named Virtual World 2012, took place in a large shopping centre, Avion. We included the AR workshop for school kids there. The aim was to teach creation of an own AR by pupils from elementary and secondary schools, or people with some programming skills. First, we demonstrated tasks manageable for a given age category, like adding virtual objects (virtual information) to the real scene (reality). Further, we explained basic requirements such as registering a 3D object and real time interaction in medicine, advertising, sport news, design, cultural heritage, and entertainment, of course.

Afterwards, the workshop continued with the practical part to familiarize the participants with the selected tool (ZooBurst.com) to create their AR message. The youngest authors prepared their own fairy tales, which appeared in the reality of the image webcam on the computer, using printed black and white images (marks, marker). The secondary school students worked in Flash, using Flartoolkit, which allowed them to combine their own 3D model with their own AR application.

The "adult informatics" authors were challenged with ARtoolkit, multiple markers and 3D objects. They were provided with explanations of algorithms used to detect markers and display 3D models. Our main concern was that each participant, after graduating the workshop, understood the concept of AR and had sufficient mastery to create his/her own AR application. We can conclude that this sort of “novelty” interestingness is positively influenced by their own creativity.

Figure 4. Photo from the workshop for high school students, the AR was created using Artoolkit.
Source: Own work

CONCLUSION

We selected an overview of AR ideas in the context of the related field of VR systems, which serve to support imagination, interaction and immersion. The importance of immersion for AR systems evaluation is expected to grow (Schmalstieg and Höllerer, 2016). Naturally, the quality can be measured either by standard didactic quantitative or qualitative methods, but the research in virtual museology offers more matured authoring and success metrics. The authors (Cameron and Kenderdine, 2010) combine theory of appraisal and ideas from rhetoric into a promising double theoretical framework. However, we propose to think practically, in terms of global and local interestingness as devices to improve engagement, user experience, immersion. Virtual museum authoring and research offer valuable alternatives of educational inspiration. For specific maths-oriented educational purposes, we recommend studying and enriching the Construct3D research line.

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AUTOMATED TESTING AS A LEARNING ASSESSMENT TOOL FOR UNIVERSITY STUDENTS

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Abstract: *The paper considered and analysed aspects of modelling elements of knowledge test assessment. Learning process is a continuity of consecutive study of individual parts of the course and disciplines as a whole. Computer-based test assessment is gaining popularity among professors and educational managers. The authors discuss the benefits and drawbacks of digital test assessment. Computer testing is rationally applied to solve the tasks of formative and interim student learning assessment. The authors maintaim that the increase in the efficiency and accuracy of assessment is achieved not by increasing the number of test tasks, but by bringing the level of complexity of the questions to the student's level. Their approach is based on the overlay student model of student knowledge. For more reliable assessment of the individual student's knowledge the authors used the Sugeno fuzzy inference method.*

Keywords: higher education, knowledge assessment, adaptive test assessment, fuzzy logic

INTRODUCTION

In modern conditions, the system of higher education in Ukraine is focused on new educational technologies, which are connected with reduction of compulsory presence hours and increase of the share of independent work of students. In this regard, it is necessary to improve the learning strategy and monitoring of achievements based on a particular scope of individual knowledge, skills and abilities of the learners. In order to implement individual approach to every student we must carry out a qualitative and quantitative analysis of their knowledge and skills correctly (*Nacional'na doktrina… 2001*).

Monitoring allows establishing feedback between the teacher and the students, which improves the assessment of dynamics in the knowledge acquisition; it allows identification of the actual scope of knowledge in the required field, skills and competences of future professionals. Monitoring is also a field of professors' practical activity and a subject of theoretical studies. With the help of monitoring one can identify the advantages and disadvantages of new teaching methods, establish the relationship between the planned scope of learning and the actually achieved ones, compare the performance of different teachers.

The analysis of the obtained assessment results is a complex multifactorial correlation with a large number of variables, which often requires large investment of effort and time for statistical calculations. However, conducting such monitoring of students' knowledge, skills and abilities is an essential component of the learning process.

It is becoming increasingly important to hold pedagogical diagnostics of the results of educational activity in order to further improve the educational process. One of the tools to assess students' knowledge during the study of disciplines is a test system. Computer technologies play a vital role in the organisation of the modern educational process.

Evaluating the quality of learning using computer technology can significantly reduce the time and effort invested in analysis and it also increases the informativeness of results. Let us stress the fact that computer testing today is the most objective method of pedagogical monitoring. Therefore, the aspects of algorithmization and designing tools for computer-based test assessment of skills and abilities are of particular interest.

Particularly relevant is the development of algorithms and software aimed at automated solving of identified problems, which will increase the objectivity of knowledge assessment through the accumulation of data about student achievement and adapt the process of automated testing to the level of knowledge and psychophysiological characteristics of a particular student.

1. ANALYSIS OF RECENT RESEARCH

A lot of research works are devoted to the application of information technologies and the designing of student testing systems. Lizunov, Teslya, Zyanchurina, Nekrasov, Rizun, Taranenko suggest systematic account of the organizational problems in the development and application of computer testing technologies in high school. A group of authors (Zagrebel'nij, Shcherbina, Fedoruk, Artamonov, Kravchenko, Babij, Kravchenko) consider methods of adaptive testing of students' knowledge and practical aspects of computer-aided adaptive learning and testing. Research in the field of knowledge testing automation is aimed at: increasing the effectiveness of the hardware and software design of the test session (Cidelko, Yaremchuk, Shvedova; Veligura, Lekhcier, Tkachenko), the analysis of experience using automated testing systems (Katerinchuk, Naumenko, Abakumova, Kovaleva).

The purpose of the paper is to provide a theoretical justification for testing as a means of improving the quality of the learning strategy and assessing student achievement, based on the level of individual knowledge, skills and abilities of the student being taught. Research objectives: theoretical literature review of automated student testing systems; description of test banks for computer-aided assessment of student's level and structure of knowledge, development of an algorithm for computer testing, with an account of student's model, the complexity of test tasks, the time to cope with it.

2. RESEARCH RESULTS

The analysis of research and personal experience in using computer-enhanced knowledge assessment shows its superiority over traditional methods (Katerinchuk, Naumenko, Abakumova, Kovaleva). The suggested approaches allow creation of a system of pedagogical testing and increased efficiency of teaching process in any course.

2.1 Drawbacks of computer-based test assessment

To date, there is quite a large number of automated testing systems that declare the ability to provide quality control of knowledge. In general, the work of modern developers emphasizes the efficiency of computer-aided adaptive testing, its effectiveness in the selection of tasks for each individual student, and obviously, saving time for the testing process itself from the student perspective (Louhab; Conejo; Tseng).

The choice of software depends on the purpose of the test. TestMaker, Moodle, Kahoot software complexes are currently in high demand and are quite attractive software products. However, when using the Moodle software system, users might report problems with obtaining high-quality technical support, so universities must have an experienced Moodle expert to deploy and maintain the system; professional enhancements may be required to extend functionality or correct software errors that occur in the system. TestMaker software might look a bit outdated in terms of interface, it also has irregular software updates. While using Kahoot! some students may have problems downloading on their mobile devices in case of poor internet connection.

As an automated form of knowledge monitoring and assessment computer testing has a number of vulnerabilities and due to its strict algorithmization it is subject to its probabilistic risks. This can manifest itself in the following:

1. The development of efficient test tools is a long and demanding process requiring high qualification and increased attention of a teacher or methodologist

who not only prepares the required number of test tasks, but also ensures their differentiation in terms of complexity;

1. It is impossible to figure out the causes and origins of deficiencies in students' knowledge of specific sections of a course, directly after the detailed test results;
2. Elaborate assessment of the thorough understanding of the subject, mastery of the style of reflection, typical of the course in question. During test assessment the student, in contrast to oral or written exam, does not have enough time for in-depth analysis of the topic, while the possibility of choosing between several suggested answers does not allow evaluation of skill of formulating their own answer and does not contribute to the development of skills to support their answers;
3. The test does not allow the teacher to check and evaluate the productive levels of knowledge associated with creativity, that is, probabilistic, abstract and methodological knowledge;
4. It does not promote the development of oral and written language of students. With random answers, the student becomes accustomed to working with ready-made wording and is not able to reproduce the absorbed knowledge in a competent language;
5. When analysing the data obtained it is necessary to take into account the probabilistic component, which distorts the results of the test and suggests a superficial representation of true knowledge and skills of students. At testing there is a chance of guessing the correct answers, and thus, there is no guarantee of solid knowledge in students. On the other hand, an accidental mistake is also possible in well-trained students, while the availability of several variants of answers, very similar to each other, often misleads some of them;
6. A possible loss of individual approach, as testing involves common rules, which all students are asked to follow. At the same time, there is a significant risk of overlooking a bright individuality of an unconventional mind;
7. Ensuring the objectivity and fairness of the test requires special measures to ensure the confidentiality of test tasks. When re-applying the test, it is desirable to make changes to the task, that is, there is a need to constantly update assignments and answers. On the other hand, designing efficient test tasks requires a preliminary empirical check and stable indicators of validity and reliability.

2.2 Proper place for computer testing in the curriculum

The above mentioned disadvantages suggest that computer testing cannot be the only one and universal way to test knowledge. This means that a reasonable combination of traditional assessment tools and test assessment techniques is required. To date, any taken technique of testing has a specified area of application and solves a limited range of tasks. Therefore, in our opinion, the final assessment in the university should remain traditional: exam, credit, course paper and graduation paper. Computer testing is rationally applied to solve the tasks of *formative* and *interim* student learning assessment.

Formative assessment is the main type of monitoring the student's acquisition of each course. Its main task is the regular management of student learning and its adjustment. It permits to get fundamental data about the progress and quality of the educational process. The data received after formative assessment is crucial for managing the learning process. The tasks of the formative assessment are basically the following:

- to reveal the scope, depth and quality of the student's perception and acquisition of the material;
- identify deficiencies in knowledge and outline ways to eliminate them;
- to find out the degree of students' motivation and their attitude to systematic work;
- to inquire into the reasons that hinder their work;
- to define the efficiency in mastering the skills of independent learning and identify the ways and means of their development;
- to stimulate students' interest in the course and their eagerness to learn.

Formative assessment is carried out on almost every lesson in the process of mastering the new study material (topics, lectures). Herewith, it is not recommended to allow significant intervals in assessment, because otherwise students will stop regularly preparing for classes and consolidating the material they have learnt. Formative assessment should take a small part of the classroom time so as not to rush into the presentation of new material and consolidation of the information absorbed. It is advisory to conduct formative assessment based on a set of control tasks, prepared by the teacher in advance and not exceeding the volume of 10 - 15 tasks. With formative assessment we achieve current progress, the learning process becomes manageable and students' cognitive activity gets stimulated.

Interim (cross-sectional, modular) assessment permits to evaluate the quality of knowledge absorbed by students in several sections or topics of a course. This assessment usually takes place several times a semester, and this allows you to test the quality of the acquired knowledge through a longer period and covers more substantial sections of the discipline, which allows the identification of logical interactions with other sections. Interim assessment permits to check the assimilation of the acquired knowledge and skills, design individual learning scenario for each student, which permits to adapt the system of presenting new material and recapitulation units of material studied before. Accordingly, the method of assessment changes and students can be expected to get involved in independent constructive activity.

2.3 Aspects of adaptive testing

It is expedient to carry out interim assessment using adaptive test evaluation. The appropriateness of adaptive knowledge test assessment stems from the challenge of streamlining traditional testing. The main idea of this approach is that the increase in the efficiency and accuracy of assessment is achieved not by increasing the number of test tasks, but by bringing the level of complexity of the questions to the student's level. In most cases, this is usually associated with a decrease in the number of tasks, time, cost of testing and with an increase in the accuracy of the points obtained by the students after the test.

Adaptive testing methods involve the editing of the composition and sequence of the test tasks presented in the testing process on the basis of known regularities inherent in the test tasks bank and the information received from the respondent (student) during the testing.

One of the basic components of adaptive testing systems is *student model* that provides knowledge on the subject of a learning system that is needed to support decision-making when organizing a learning process to achieve learning outcomes. It contains quite comprehensive information about the student: psycho-physiological individual characteristics, level of student's knowledge, skills and abilities, ability to study, ability to perform tasks, ability to use the information received, personal characteristics and other parameters. The student model is dynamic, i.e. it changes in the course of studying the discipline, during the work with the system and therefore depends on the method of modelling the subject area. *The model of a student's level of knowledge* comes from the student model and includes types of educational and cognitive activities to acquire specific knowledge, skills and abilities.

Today, many colleges are developing their own comprehensive computerized systems designed to effectively control and evaluate students' knowledge. In 2018 the authors questioned professors and students of Dniprovsky State Technical University (Kamianske, Ukraine) about the necessity of using computer testing as an automated form of pedagogical diagnostics. 296 respondents were interviewed: 37 of them were full professors and 186 associate professors. The age structure of respondents: up to 50 years - 40%, 51 - 80 years - 60%. 86% of respondents support testing as a way to test students' knowledge, 14% oppose to its use. Such support is associated with widespread adoption and implementation of ICTs in university teaching.

According to the results of student survey the necessity of using computer testing was supported by 95% out of roughly 5000 students. As to the reasons ~~why~~ most answered that this is one of the requirements of the modern world for effective management of education of various levels.

Currently, professors at the department of Electronics are developing and implementing a test system for the students in the course Digital circuitry, for internal use.

In order to model the level of knowledge, the authors chose overlay model of a student (Popov, Lazareva 2015) – representing the student's knowledge as a subset of the model of subject domain formed by an expert (lecturer). In the model domain you can find several levels of hierarchy. A didactic unit can be considered the minimum structural unit and logically independent part of the educational material. The overlay model assumes that all knowledge in the course of training is divided into some independent parts (elements). For example, all training material consists of a set of topics L and a set of assessment tasks *TZ*, the implementation of which is intended to assess the quality of learning material. For each topic $l \in L$ there is a set of tasks $TZ_l \subset TZ$, and the following conditions are fulfilled: $\bigcup_{l \in l} TZ_l = TZ$ та $\forall l_1 \in L$, $\forall l_2 \in L\, TZ_{l_1} \cap TZ_{l_2} = \varnothing$.

Each level of the model of the subject area corresponds to the level of the student's knowledge model. A numerical attribute is assigned to each topic of the subject area which shows the student's understanding of the material on this topic. Moreover, the degree of assimilation of each of the knowledge units can be estimated by a percentage or probabilistic coefficient. The value of this attribute will be determined during the formative assessment. The current state of the learning process is, in fact, the projection of student's knowledge onto the domain model.

The overlay model stores data about student achievement for each area of knowledge of the subject domain. The results of performing a TZ set of test tasks during formative assessment permit to form a set of grades (O) for the student's success in learning the course material. Conducting test assessment on a specific topic TZ_l allows students to get an adequate assessment of its assimilation $O_{l_i} \in O$, so the overlay model allows you to identify what the student knows or doesn't know. At the initial stage, the model contains a very small amount of knowledge about the student, therefore, cannot give an adequate assessment, and therefore, cannot be used for adaptation. On that ground it was decided to use adaptive testing for the organization of interim assessment.

There are various ways to assess the scope of mastering a discipline for a certain length of time, or in general, based on data on the scope of mastering teaching units. In the simple case, they set, by default, the parameters equal for all didactic units and the average estimation of the level of knowledge of each student is calculated as follows:

$$O_{c_i} = \left(\sum_{i=1}^{N} O_{l_i}\right) / N$$

where: i – task number, which is connected to didactic unit;

N – the number of tasks to assess all didactic units for a given period of time;

O_{l_i} – the result of i-task.

Using the dynamic overlay model of student knowledge allows you to determine the degree of assimilation of didactic units for a certain period of the learning process. Based on this information, students can be divided by the degree of mastering the discipline in four levels:

1. Level R_0 – "fail" or "inadequate achievement", if $O_{c_i} < 60$;
2. Level R_1 – "minimal achievement" or "satisfactory", if $60 \le O_{c_i} < 74$;
3. Level R_2 – "extensive achievement" or "good", if $74 \le O_{c_i} < 90$;
4. Level R_3 – "exceptional achievement" or "excellent", if $90 \le O_{c_i} \le 100$.

The applicability of adaptive testing methods is based mainly on the complexity of test tasks. Adaptive testing is a variant of automated testing system where the parameters of complexity and differential ability of each task are obtained in experimental way and are known in advance. Thus, before becoming a part of computer bank of test tasks, each of them undergoes empirical testing on a fairly large number of typical respondents.

The solution to this problem is possible by means of formative assessment, where the modern theory of Item Response Theory (IRT) is used for the statistical processing of the answers, the IRT being based on the Rasch model (Rasch, 1980). A prerequisite for the application of Rasch model is that all selected test tasks should be offered to each student. As a result, we get a dense matrix of test results, statistical processing, which allows you to get latent parameters of student's level of knowledge and complexity of test tasks. This approach can improve the quality of testing and eliminate random errors in the development of test tasks. Relying on the results of determining the complexity of test questions and the traditional classification of the scope of learning, one can divide all test tasks into several levels:

1. Level TZ_1 - level "satisfactory". The test tasks of this level can reveal the student's: basic knowledge of the course, general concepts, knowledge of terminology, formulas and laws. This kind of assessment tests the ability to act according to a model or a known algorithm. This is the basis, which lays foundations for the second more complex stage of testing.

2. Level TZ_2 – level "good". Testing aimed at verifying how successfully a student can make logical conclusions and operate basic concepts within standard, typical situations. Testing determines the knowledge of certain algorithms, formulas, laws (regularities) when performing standard tasks, the ability to conduct a situation analysis, use knowledge from different areas, topics. At the second level reproductive thinking is checked. Based on this type of thinking solutions are worked out.

3. Level TZ_3 – level "excellent". Testing evaluates the ability to find the optimal, rational solution in non-standard situations, in non-typical tasks. This is the most complex part of the task bank, which requires students to design new, previously unknown solution algorithms, explore possible solutions, act in a non-standard situation.

One of the important factors in the testing process is the time given to the answer and the time spent by each participant in the test. Exceeding the time to answer the test task can be considered not sufficient student's mastery of the material outlined, or as the use of third-party sources of knowledge by the student. Too little time spent by the student on the solution of the test task should signal the system either about inappropriate level of complexity of the tasks of this type for a particular student, or about the student's knowledge of the correct answer to this task in advance, or about simply guessing the correct answer. Small response time also indicates the need to revise the corresponding test task, which may be incorrectly constructed and the correct answer is in the question itself, that is, there is a tooltip. In any case, all these cases give an error in assessing the student's actual knowledge and this requires the introduction of a system of penalties, that is, the assessment should be reduced.

2.4 Fuzzy logic improves adaptive test assessment

We used the Sugeno fuzzy inference method for a more reliable assessment of the individual student's knowledge, taking into account the time spent on the answer. It is suggested to design the methodology for assessing the quality of students' knowledge using methods and means of artificial intelligence implemented in the Fuzzy Logic Toolbox package of the MatLab system in the form of Adaptive Neuro – Fuzzy Inference System (ANFIS). The ANFIS hybrid system is a combination of a neuro-fuzzy Sugeno method of deducing an artificial neural network of direct propagation with one output and multiple inputs that are fuzzy linguistic variables (Figure 1).

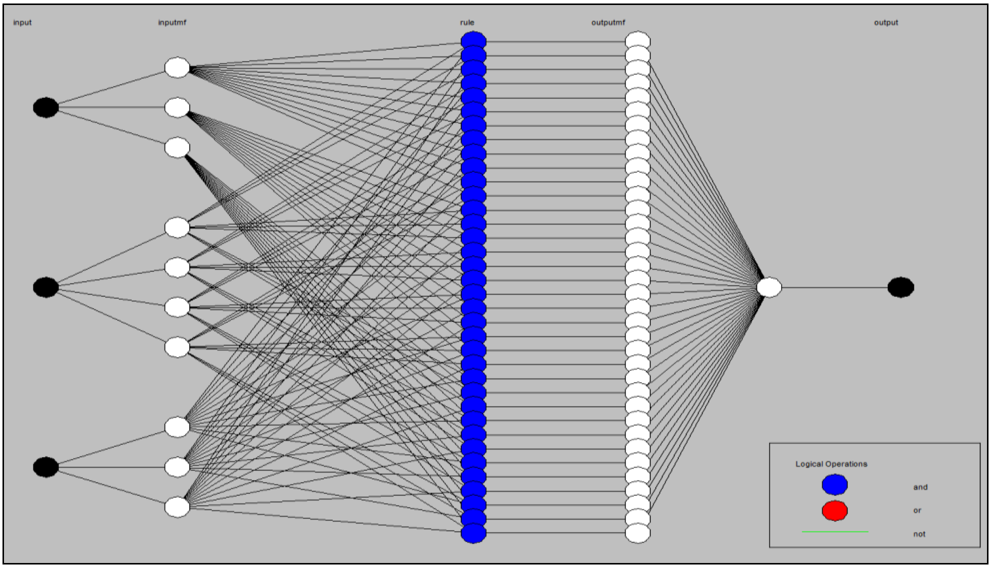

Figure 1. Neural network built in MatLab system
Source: Own work

Three fuzzy linguistic variables were considered input parameters for the system, (Figure 2):

1. "Rate of performing", which is interpreted as a term-set of values T1 = {Quickly, Norm, Slow}.

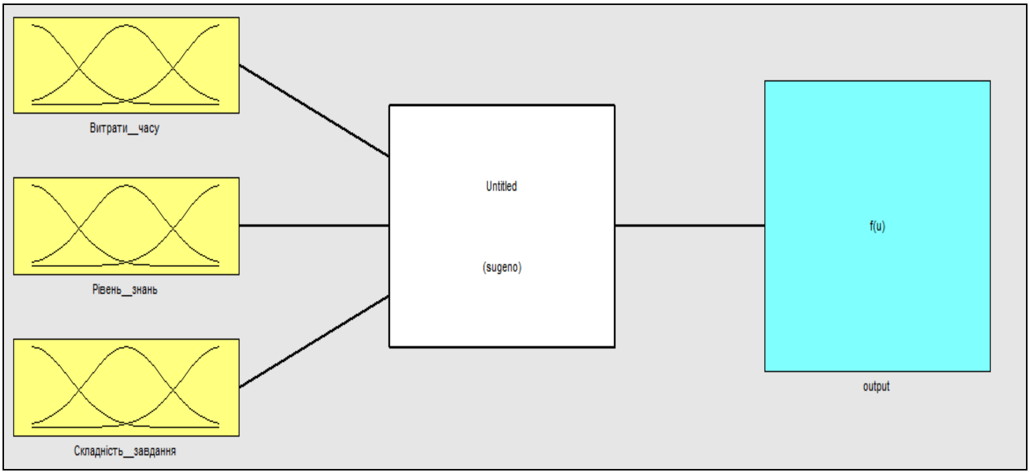

Figure 2. Input system parameters for the Sugeno method
Source: Own work

2. "Scope of knowledge", which is interpreted as a term-set of values T2 = {Poor, Satisfactory, Good, Excellent}.

3. "The level of complexity of the assignment", which we interpret as a term-set of values T3 = {Complex, Medium, Light}.

The output variable is k_s – the credibility coefficient, which we will define in the range from 0 to 1. The coefficient characterizes the decrease in the rating in case of violations of the testing procedure, for example, when the participant exceeds the time allocated for the execution of the j-task.

As a result of the analysis of the domain, a base of rules for estimating k_s is formed, which consists of two parts: input and output. The input consists of statements, connected by "I" bonds. In this case, the concluding rule is presented as follows: if (the pace of performing is fast) and (scope of knowledge - low) and (the level of complexity of the question is high) then (the coefficient of credibility - k_1) etc. The coefficients $k_1, k_2, ..., k_s \in [0,1]$ - characterize a decrease in assessment in case corresponding violations of the testing procedure take place. The surface of the fuzzy output obtained via the developed model is shown in Figure 3.

The total score, comprising the points awarded for the correct answers in the entire test, is calculated as follows:

$$O_{i\,\Sigma} = \frac{\sum_{j=1}^{m} k_{ij} a_{ij}}{a_{\Sigma\,max}} \times 100$$

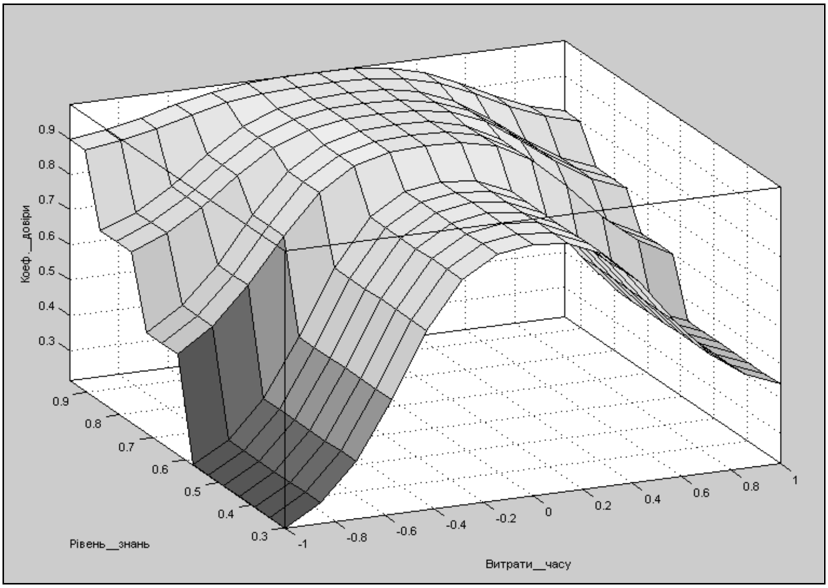

Figure 3. The surface of the fuzzy output for the value of the coefficient k_s
Source: Own work

where:

α_{ij} - the result of i-th participant for the j-th task: 1 - the answer is correct, 0 - is not true;

$a_{\Sigma\max}$ - the maximum number of points for performing all test tasks;

k_{ij} is the credibility coefficient obtained through the system of fuzzy predicative rules by the i-th testing participant for each j-th test task.

2.5 Rules for efficient algorithms of adaptive test assessment

Based on analysis of results of the conducted research, we developed an algorithm of test control with block adaptation, where the decision to change tasks is made after analysing the results of testing in the previous block of tasks. The scenario of performing adaptive test is based on the following rules:

1. Using the database, the testing module carries out the identification of registered or new users, the selection of the test, tests the student by displaying the task on the screen and expecting the solution, processes the received data and records the results of testing to the database to allow further analysis and use by the teacher.

2. At first, the system puts a block of test questions of the lowest complexity (10-15 questions) to all respondents.

3. The respondent who has knowledge above the current level of complexity has a chance of early transition to a more complex level. The transition is carried out under the following conditions:

- correct answer to the first three questions of the test;
- correct answer to four questions out of the first five questions.

4. The respondent whose scope of knowledge is lower than the complexity of the tasks can complete the test ahead of time if the answers to the three questions in a row are incorrect.

5. A respondent whose scope of knowledge matches the complexity of the questions takes the whole test given, and if he or she produces 80% or more correct answers, then the system transfers the student to a more complex level.

6. The test assessment is completed on the following conditions:

- all questions in the bank of test tasks are processed;
- the scope of knowledge is assessed with sufficient accuracy;
- the student reached the end of the test;
- the respondent shows his or her incapacity to process the test questions.

Here are some of the developed test tasks for the course Digital Circuit Technology at the Department of Electronics of DSTU. The automated testing system is based on the client-server principle. With this approach, you can use all parts of the system from a variety of devices, starting with phones and ending with home computers. To use the system on your device, you need a Web browser program and Internet connection. When designing the system architecture, the principle of modularity was used for greater elasticity and convenient completion of the project in the future without the need to edit existing working structures, models and controllers. Taking into account the server approach chosen, the list of tasks and requirements was chosen by the system of storage of MySQL information in the language of SQL queries.

For the implementation of automated testing system, the best choice for the system platform is the Laravel framework. Laravel supports working with the selected database type and is created in PHP programming language. Laravel is a free, open source PHP framework.

An important feature of the test tasks in this course is rich use of non-verbal information, namely graphic information in the form of diagrams, graphs, waveforms, diagrams and more. Such information is used not only in the formulation of test tasks but also in the formulation of variants of answers. Using graphical information allows:

– stimulating higher level cognitive processes;
– making testing less tedious, more varied;
– reducing the number of accidental errors;
– arousing interest in the task and is an additional motivation in completing the test task.

Most often, they use tests where students have to choose one correct answer from the proposed answer options. These tasks consist of the following mandatory parts: 1) instructions; 2) the substantive part of the task; 3) a certain number of proposed answers (answer options); 4) reference answers; 5) evaluation systems. An example is shown in Figure 4.

The structure of a simple test task includes a question and several (at least two) answer options (one is sure to be true and the other is definitely not). A "key" is always added to the task - the correct answer (standard), which compares the answer and concludes that the task is done correctly. If the respondent's answer matches the standard, the statement becomes true, if not - the statement is false.

The purpose of the closed-circuit vehicle is to assess the ability to form a system that is relevant for testing from the proposed sign concepts. Probability of guessing the answer in the test with the choice of one correct answer:

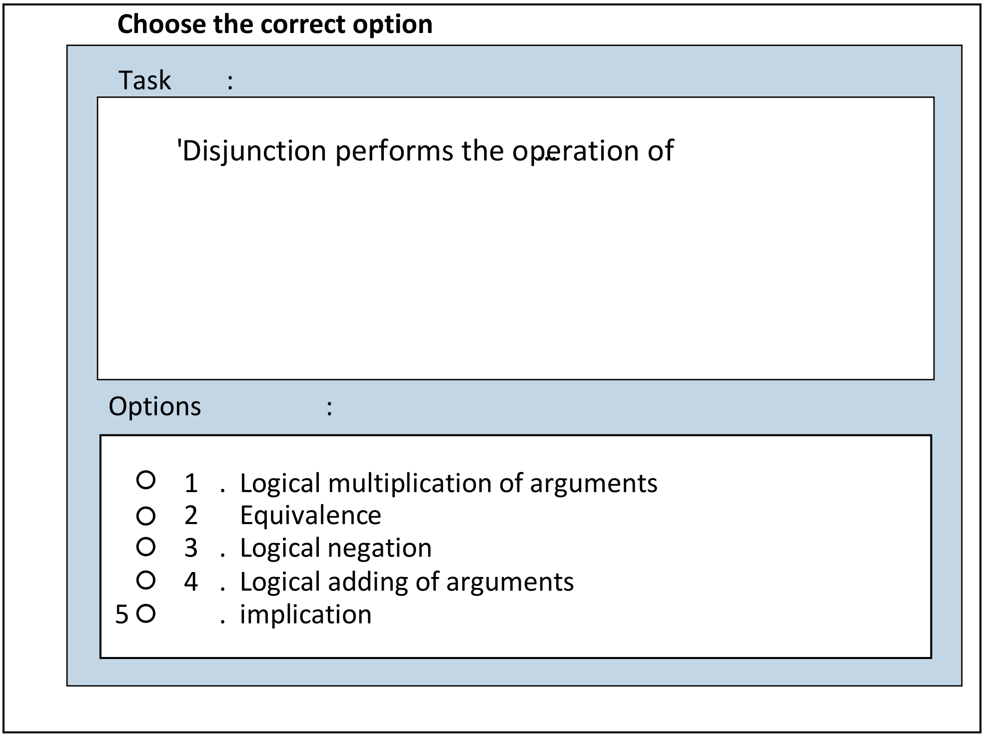

Figure 4. A test task with the choice of one correct answer from the suggested options

Source: Own work

$$p = \frac{1}{n}$$

where n is the total number of answer choices.

In tests of this type, n is 4 or 5; thus, the probability of guessing is 20 - 25%. Of course, this is a large value, so this form is used only in the simplest test tasks of the first level of difficulty, designed to test knowledge of any mandatory provisions (rules, laws, etc.). It takes 10-30 seconds to complete a simple closed-form test with one element selected.

The test of this form is most prone to the risk of cheating, clues, and other undesirable phenomena that distort the objective picture of students' knowledge in the context of even a well-organized testing process. Therefore, the developer is faced with the problem of creating several variants of tests with similar content and the same complexity.

The problem is solved by the development of 5 - 8 parallel variants of the test, for which you can use facet tasks. The facet is understood to be a form that provides the presentation of several variants of the same element of the content of the vehicle. In addition to single-facet tasks, there can be two, three or more facets.

Each student receives only one option from the facet. In this case, all test groups perform the same test, but with different elements of the facet and, accordingly, with different answers (Figure 5). Thus, two problems are solved simultaneously: eliminating the possibility of cheating and creating tests with the same characteristics.

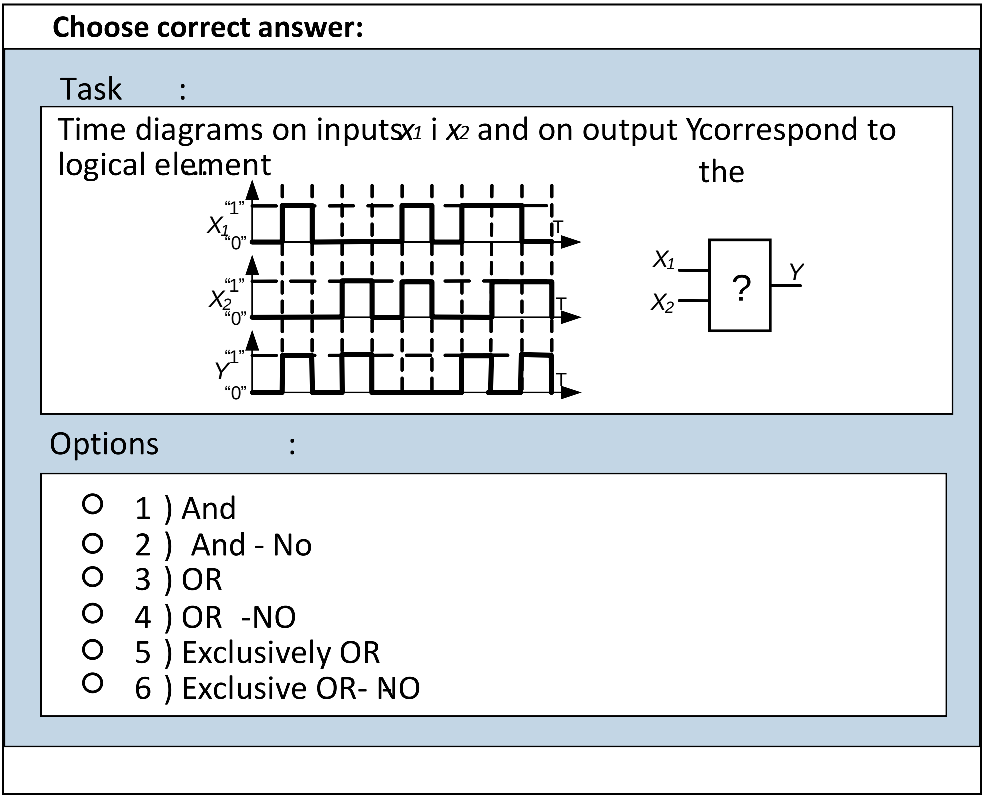

Figure 5. Facet test tasks with the choice of answers out of suggested options

Source: Own work

The form of the test questions with the choice of answer is a task for which there can be several options. The substantive basis of the tasks of this form is mainly classifying knowledge. The answers to the task must necessarily refer to the same kind or type of notions. In these test tasks the students should select all the correct answers from the list of options offered. In doing so, the instruction may indicate or not how many correct answers the student is giving. In the second case, the peculiarity of this form of task is that it is necessary to determine not only the correct answers, but also independently evaluate the completeness of the answer.

The principles of creating test tasks with multiple answer options are the same as the task of choosing one correct answer, only the number of proposed answers (distractors) can be increased at the discretion of the author to 5 - 12. But it is not necessary to make too cumbersome tasks as it is difficult for the student to keep too many content elements in memory at a time. Such a task can be regarded as combining n (by the number of answer options) of single-choice tasks, each of which independently of the other can be either true or false. The probability of complete guessing is equal to the product of the probability of guessing each question, which is p = 1/2. So:

$$p = \left(\frac{1}{2}\right)^{n}$$

For comparison: with n = 5, the probability of guessing is p = 3%, i.e. it turns out that with the same number of response options in the selection tasks, multiple choice provides a lower probability of random execution of the task than with the choice of one correct answer (p = 20%) .

The format of test tasks aimed at restoring the conformity of parts is a modification of multiple-choice test tasks and belongs to the category of logical pairs. Test tasks establish a measure of conformity of two heterogeneous large sets, which are in a known relation to each other. To establish correspondence between two objects (in this case - sets) - means to establish their dependence on each other; to establish a measure of conformity - means to identify this dependence in its entirety, that is, in terms of its comprehensiveness, completeness and uniqueness. Each set is formed by some set of elements, which can be any object, object, phenomenon, process, their components, properties and the like. The basic condition for the formation of the set is the homogeneity of all its elements, that is, the presence of common properties, signs.

A task of this type consists of a task statement and two or more columns. One column (left) is a list of initial conditions (words, phrases, sentences, dates, formulas, terms, etc.) to which the respondent should find the answer in the second column (right), which is called the list of answers (Figure 7). Response options are usually indicated by letters, and words or phrases containing the task are numbered.

The respondent should compare the material of the left and right columns and form the correct logical pairs. Consistently comparing each element of the set of initial conditions with the elements of the set of answers, the respondent finds out which of them are interrelated and which are not. This should be guided by the kind of relation between sets, which is determined by the condition of the problem and therefore, serves as a guide when finding interdependent elements.

The greatest difficulties in designing are related to the selection of plausible redundant elements in the right set. The plausibility of each distractor is empirically established. Each answer variant can be used more than once or not used at all, so the task of this format cannot be executed by the exclusion method.

In fact, such test tasks are a task of choice; only the choice with respect to each of the n elements of the first set is made with the m variants of the answers contained in the second set. The probability of guessing:

$$p = \left(\frac{1}{m}\right)^n$$

For example: at n = m = 4, the guessing probability is p ≈0.4%

The assignments for establishing the correct sequence are used to test the knowledge of the sequence of certain actions, algorithms of execution, events in time, as well as definitions and concepts, etc. They help to form students' algorithmic thinking, knowledge and skills. Tasks of this form can be used as a means of controlling knowledge and skills, as well as a means of training (Figure 6).

At each step, one of the remaining correct answers is selected. The probability of complete guessing of all the answers of the task for N elements in the sequence will be equal to:

$$p = \frac{1}{n} \cdot \frac{1}{n-1} \cdot \ldots \cdot \frac{1}{2}$$

Thus, if the number of elements in the sequence is n = 5 the probability of guessing is p = 0.8%, and if n = 6; then p = 0.14%. It is possible to note the extremely low probability of guessing the correct answer characteristic of this form of tasks. However, in many cases the task of establishing the correct sequence is extremely non-technological or unsuitable because of the specific content of the subject matter. They are cumbersome and often allow for an ambiguous sequence of responses.

The variety of forms of test tasks used ensures their differentiation by the level of complexity, which, in turn, is necessary for differentiation of students by the level of academic achievement. A number of recommendations should be made:

1. An easy test task:

- is aimed at "learning" an object or to test "knowledge-recognizability";
- is aimed at choosing one answer from many with the knowledge of only one concept;
- the open type is aimed at revealing knowledge of the definition of a single-component base term;
- aimed at disclosing the basic concept;

– reveals the lowest level of the test specification hierarchy (for example, some "concept").

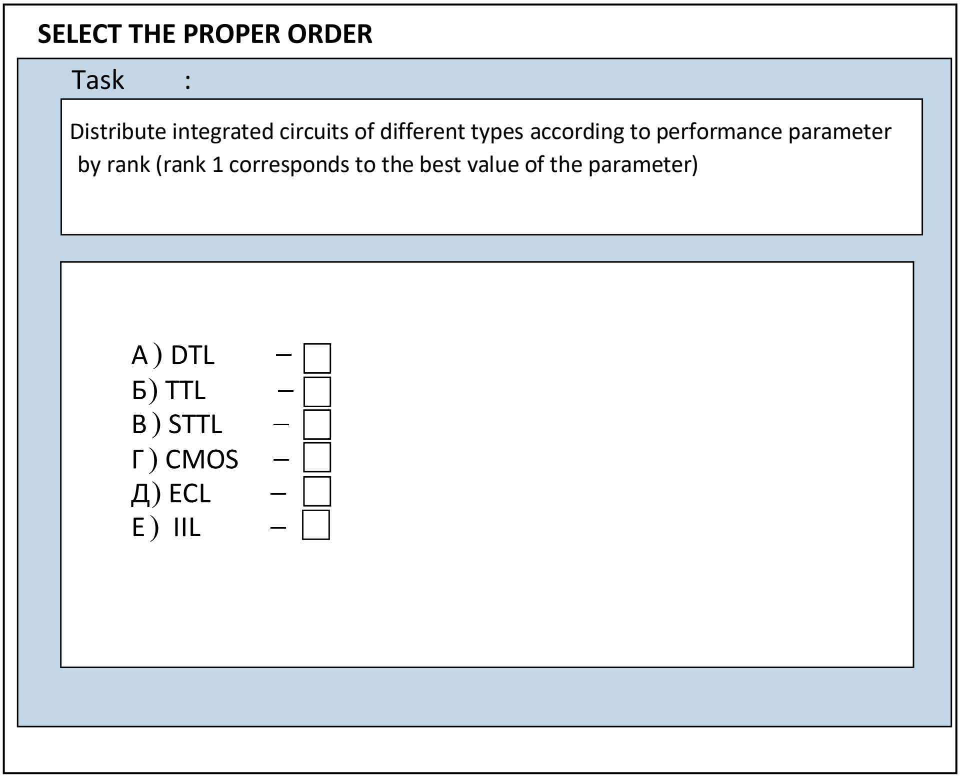

Figure 6. Test task to restore the order
Source: Own work

2. Tasks of medium level of complexity :

– are aimed at applying previously acquired knowledge in typical situations;

– reveals the average level of test specification hierarchy (for example, a topic or subtopic).

3. A complex level tasks:

– are aimed at applying the acquired knowledge and skills in non-standard conditions (i.e. in conditions not previously familiar to the subject);

– aimed at testing knowledge, skills and application;

– aimed at checking additional material;

– reveals the top level of the test specification hierarchy (for example, sections, chapters).

CONCLUSION

The offered method allows implementation of an individual approach in teaching, selection for the purpose of independent study exactly the educational material that is necessary for a particular student at a given point of time. The use of adaptive testing promotes the development of modern areas of education and opens up new opportunities to improve the efficiency of learning processes, provides more objective assessment of knowledge, skills and abilities, and also allows you to save time and, consequently, the cost of assessment. Implementation of this method should be balanced, so that this knowledge assessment procedure is well integrated into the learning process to ensure its maximum efficiency.

This testing technique requires considerable time to develop individual test sets, but the focus of the test on the content of individual classes allows you to implement this system for individual topics from the very beginning of its development. Further testing of the described methodology and statistical analysis of the obtained results is envisaged because only after conducting multiple statistical treatments can we talk about creating a test with stable quality parameters such as reliability and validity. The results of the research can be applied in the development of test sets for other courses.

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STEM EDUCATION: PRACTICE-ORIENTED TOOLS FOR TEACHERS OF MATHEMATICS

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Abstract: *The article is devoted to the study of the possibility of realization of STEM education in Ukrainian schools, selection of appropriate tools of modern pedagogical and information technologies for organizing STEM education in the mathematics classroom, methodological training for mathematics teachers to this activity, development of innovations, readiness to use IT technologies in the realization of inter-subject links, development of the individual's creative potential, their pre-service training.*

Keywords: STEM education, teaching mathematics, methodical teacher training, inter-subject links.

INTRODUCTION

The pace of technology development contributes to the increasing demand for engineering and IT-specialists, professionals of high-tech enterprises. Accordingly, there is an increasing interest in scientific and technical components at all levels of education. (Morze, Gladun, Dzyuba, 2018)

The activation of STEAM education is one of the ways to solve a number of educational problems. Now in Ukraine, teachers work in the conditions of updating of the educational model as well as the implementation of new approaches and teaching technologies, including STEM and STEAM education within the all-Ukrainian project "STEM School" on the platform of the Ukrainian project "Quality of Education" (InnovatsIyniy proekt «STEM-shkola», 2017, Nakaz MON Ukrayini, 2018)

In these conditions, the training of teachers, who are capable and ready to solve interdisciplinary tasks, to implement project-oriented activities, to apply innovative teaching methods is of particular importance. It is useful to provide such training in higher education institutions even while training future teachers.

However, despite the increased interest of modern researchers in the field of pedagogy, didactics and mathematics teachers, the technology of STEAM education is being introduced into the educational process of secondary schools of Ukraine rather slowly. Given the above, an important task of higher pedagogical educational institutions is the targeted preparation of students - future mathematics teachers - for the implementation of this technology in their future professional activities.

The purpose of the article is to highlight the results of a study of the attitude of teachers and students to the problem of using STEAM education technology in the educational process of a comprehensive school.

Research methods: analysis of the problem in the pedagogical and methodological literature regarding STEAM education, a survey of practicing mathematics teachers and students of the Faculty of Physics and Mathematics.

1. IMPLEMENTATION OF STEM EDUCATION IN UKRAINE

The support of STEM education in Ukraine, as well as in the USA, Japan, South Korea, Israel, Great Britain, and others, is at the state level. Since 2016, systematic work on its implementation with the aim of "the innovative development of the subjects of the natural-mathematical cycle, research work in educational institutions" has begun. (Nakaz MON Ukrayini, 2016)

Over the past few years, much has been done for this: a "Web-STEM school" has been created, the tournaments are held, the All-Ukrainian "Robotrafic" competition and grants are played out, scientific and methodical materials are developed for teachers to implement and develop STEM education in the institutions of the general secondary and out-of-school education. By STEM education we mean the relevant pedagogical technology of formation and development of critical thinking, cognitive and creative qualities of school students, who are able and ready to solve complex tasks, cooperate, and implement innovative activities. At the same time, we consider STEM education in mathematics as a purposeful process of transferring and mastering knowledge, skills and methods of cognitive activity of a person, based on the interdisciplinary approaches in the creation of educational programmes at various levels, individual didactic elements, studying the phenomena and the processes of the surrounding world, solving problem-oriented tasks. This approach to studying contributes to the popularization of engineering and technical professions among young people and the formation of sustainable motivation in the study of the disciplines of the natural-mathematical cycle.

The idea of using methods of diversified development in education is not new. For example, there is the SEL concept, which implies the development of children's social and emotional skills, the method of phenomenon-oriented training and teaching PBL, similar to STEM in the way we attempt to combine different disciplines when studying a particular topic. (Anisimova, Shatunova, Sabirova 2018)

In Chicago (2011), for example, the Scientists for Tomorrow (SfT) initiative has been supported. The SfT initiative is aimed at using the education program, based on STEAM. Within its program, young people of different ages, in their free time, master various educational modules, such as “Alternative energies”, “Physics of sound and mathematics of music”, “People and plants”, “Robotics” and “Astronomy”. (Caplan 2017)

In our country, the relevance of STEM education implementation is no less interesting (D. Vasilyuva, K. Dmitrenko, E. Patrikeeva, O. Lozovaya, S. Gorbenko, N. Goncharova, O. Kovalenko, etc.); general aspects, basic concepts, problems and prospects of STEM education (I. Vasilashko, N. Morse, O. Stryzhak, I. Slipukhina, N. Polisun, I. Chernetsky, V. Sharko, etc.); methodical approaches to STEM training (V. Bagashova, L. Gned, L. Danilenko, N. Yakobchuk, L. Yakovleva, etc.); the use of information technology in teaching mathematics (M. Zhaldak, V. Korolsky, T. Kramarenko, O. Semenikhina, M. Burda, V. Klochko, G. Mikhalin, and others). Consideration is also given to the training of teachers of higher education institutions and secondary schools in using STEM technologies, as well as using interdisciplinary strategies in their work. (Segura, 2017. Chanthala, 2018). The received results of STEM training demonstrate raising of achievement and self-esteem of high school students and university students in the study of physical and mathematical disciplines. In our country, such research is still rare.

2. SELECTION OF TOOLS FOR IMPLEMENTATION OF STEM-EDUCATION

Since 2017, Ukrainian schools have been gradually switching to a new programme. In the 2018-2019 school year, most of the country’s first grades of primary schools switched to the programme of the New Ukrainian School (NUS). Ukrainian Ministry of Education and Science regulated the requirements for the educational space of such classes, both for primary school and for subject classrooms of all educational branches. (Zasobi STEM-osviti)

At the same time, STEM tools are considered ~~as~~ a set of equipment, ideas, phenomena, and methods of actions, that ensure the implementation of experimental, design and research activities in training. The selected tools must carry out informational, practical, creative and control functions. Institute of the modernization of the content of education in Ukraine recommends using:

– printed methodological (textbooks, electronic textbooks, teaching aids, training instructions and algorithms),

- visual aids of various types: natural (equipment, tools, samples), figurative (photos, posters, reproductions of paintings), sign-symbolic (sign models, graphs, charts, tables);
- technical: informational (computers, multimedia, overhead-projectors, copy-boards, interactive boards, document cameras, video-conferencing systems, projection desks, etc.), and controlling (simulators, devices for process diagnostics). (Zasobi ta obladnannya STEM)

The market is full of various offers of tools for education. It would be wrong to assume that the previously mentioned tools were not used by teachers in our country. The project method, interactive boards, programs “Stereometry”, “Trigonom”, “Mathematica”, “Geometry”, simulators for performing actions with fractions, etc. Currently, the range of offers and opportunities has increased significantly. Technical equipment of educational institutions allows using these resources in the organization of STEM-education. Only for primary school in mathematical educational field 55 different sets and simulators are offered under the NUS program (for the formation of calculating and computing skills, for working with geometric figures and bodies, for studying the concepts of area and volume, working on tasks, etc.). Leading global companies are also ready to offer their products to teachers. For example, Microsoft Store for Education offers free and paid tools. It includes OneNote notebook for organizing assignments and assessments, and STEM programmes for engaging each student to work in a lesson, and tools for organizing a Microsoft Teams, Sway lesson for creating publications, interactive training materials, presentations, projects, etc., a well-known application – GeoGebra dynamic math field, interactive digital training tools with visual models from the Sesavis Visual Learning Tool, the WeDo 2.0 LEGO® Education. Unfortunately, only a small part of them has versions in Ukrainian (EV3 Programming, GeoGebra Classic, GeoGebra Graphing Calculator) or Russian (Sensavis Visual Learning Tool, Polyup, GeoGebra Geometry, FMath, MyBookMachine Player, FluidMath, EquatIO, Matific) languages.

Most of them are very useful in the study of computer science, some in the study of physics, and only a few may be interesting for teachers in mathematics lessons. We considered the listed teaching tools in the context of their use mathematics teaching. We opted for free applications, the use of which is allowed in Ukraine. Let’s characterize them without touching the system requirements for software applications of Sensavis Visual Learning Tool. Teachers can use it to create visual models in the classroom, to simplify and analyze complex concepts, not only in the field of mathematics, but also in biology, chemistry, physics, geography, technology and others. School students can study the material and cooperate with their peers, as well as create their own videos. The writing tool for custom visualization allows the teacher to write directly on the screen using a digital whiteboard – without leaving the application.

Polyup makes it possible to develop logical and critical thinking in the process of solving mathematics puzzles and design algorithms.

- *EV3 Programming* is the official programming application from LEGO® Education. The app is complementary to the LEGO MINDSTORMS Education EV3 education concept, which supports teachers through a special platform and guided lessons, related to the education program. It is designed to simplify school students' access and participation in a wide range of subjects, including computer science, science, technology, engineering, and mathematics.
- *GeoGebra* is the world's leading software for dynamic mathematics that supports STEM education and innovation in the field of teaching and learning. It can be adapted to any education programme or project. The GeoGebra Geometry version allows measuring lengths and areas of flat figures. It can also be used for control. A variant of the GeoGebra Graphing Calculator program allows building graphs of functions, transforming them with the help of sliders, including parametric curves and given polar coordinates. To solve equations, find special points of functions (zero points, minima, maxima, intersection points), find derivatives and integrals. GeoGebra Classic combines geometry, algebra, spreadsheets, graphics, statistics and calculus in one easy-to-use package.
- *FMath* is a graphing application, but its first version is available only for a quadratic function.
- *MyBookMachine Player* allows integrating text, pictures, photos, video, audio, graphics, etc. into one multimedia file. In addition, each object can have an additional function (a link that opens a YouTube video, a Word document, related to a specific issue, the launch of an additional interactive exercise, for example, MasterTool, GeoGebra, students can access several different libraries from the tables of this program or only teacher's books, which the teacher uploads to this server, etc.). This, according to the authors, is the easiest way to allow someone to use a digital book in the author's personal book cloud. For such access, permission from the author has to be obtained.
- *FluidMath* is the first handwriting-based educational math application, designed for secondary and high school teachers and students. The popularity of this application is in its ease of using. It allows teachers and students to create standard mathematical situations, to compose and solve mathematical and physical tasks, using their own handwriting. For teachers, it is useful in creating dynamic learning materials for the audience. It is convenient for students to explore concepts in mathematics and natural sciences.

- *EquatIO* allows any mathematical expression, written on the keyboard or touch screen, as well as a formula, dictated aloud, to turn into clear and precise formulas on the screen. It ignores unwanted non-mathematical words, so it can be used in mathematics lessons and other STEM subjects.
- *Matific* develops skills in mathematical mastery and problem solving through game interaction. This application is intended only for school students and teachers who own the Matific service. Matific is a multidisciplinary online resource in mathematics, which is designed to provide teachers with optimal support in an effective and entertaining presentation of mathematical concepts. The content of Matific is carefully localized and compared with the education programme of each country. The Matific application combines a rich list of interactive games, differentiated for each student, which makes it an ideal means of teaching and learning. Mathematics is presented in an entertaining and simple form, children can do the tasks at their own pace, improve their abilities and skills, and also evaluate the use of mathematics in life.

In the conditions of the Ukrainian modern school, the organizational, educational and methodical work of teachers, their creative initiative, flexibility in the selection of educational material, as well as in the implementation of teaching methods and tools, is not limited by new standards and education programs. The transition to the competence-based model of STEM education and the implementation of the new methodological approaches causes a shift in focus on competence-oriented forms and methods of training, a system-activity approach, the implementation of innovative, game-based teaching technologies, case-study technologies, interactive methods of group training, problem techniques for development of critical and system thinking of school students. This is where the question arises about the readiness of our teachers to use such a technological arsenal.

3. READINESS OF MATHEMATICS TEACHERS TO USE STEM EDUCATION TOOLS

We have analyzed a number of studies aimed at exploring the learning environment, learning outcomes, learning tools, research on the STEM subject. The fullest review of research on the introduction of STEM education has been done by Devkan Kaleci, Özge Korkmaz. (Kaleci, Korkmaz 2018)

In their opinion, the number of formal learning environments for applications is quite large, but they are most often used as data collection tools. It is noted that research is conducted with the future teachers of natural sciences in selected groups. They argue that it demonstrates lack of the system research, conducted in the disciplines of STEM. When examining STEM subjects, it turns out in research, that the opinions of students and teachers are mainly collected, but the effectiveness of STEM is investigated in the students’ career. The researches are mainly explained the definitions of STEM, STEM education, and STEM integrated training. The research on the organization of STEM training and the readiness to use them in the professional activities by school teachers practically weren’t conducted.

During the 2018-2019 school year, experimental work was carried out with 32 teachers of mathematics in Odessa, who had internships, and 34 students of bachelor’s and master’s programmes at the K. D. Ushinsky South Ukrainian National Pedagogical University (Odessa), of the specialties 014 Secondary education. Mathematics, Computer Science, Physics. The research was aimed at indicating the level of readiness for STEM training, familiarizing with educational means, web resources that are applicable in STEM training.

The experimental work included the organization of an interview of the senior students of the Faculty of Physics and Mathematics and Odessa teachers who work on new programmes.

The questionnaire includes a number of open questions (the answer is given in free form), direct questions (the content of the question includes the information, which is interesting for the researcher), scaled questions (the questions, to which the respondent chooses one of the clearly formulated answers, presented to him). Separate questions are divided into blocks for the ease of filling, further processing and analysis. The main blocks of questions:

1. General information (qualification, gender and age of the respondent).
2. Professional activities of the respondent (type of the educational institution, present position, work experience, qualification category).
3. Questions, relating to the evaluation of training for STEM education of the interview participants.
4. Suggestions for improving the content of education programmes and organization the educational process in the context of STEM education.
5. Suggestions for improving the content of education programmes and organization of the educational process.

During questioning, some listeners did not fill out all the columns of the questionnaire; if the number of the completed questionnaire columns exceeded 60%, the questionnaire was accepted for processing, but unfilled columns were not included in the statistics. Therefore, data are presented in percentage terms.

The average age among the respondents was slightly over 40 years old, the percentage of women was 77.0%, and only 23.0% were men. 48.4% of the respondents from the number of listeners work in educational institutions, 41% are 4th year bachelor students, and 10.6% are 1st year master’s degree students of the specialties of mathematics teacher, computer science teacher, physics teacher. (Figure 1) The majority of the respondents among the teachers are teachers of the highest category (62.5%), the second category are 37.5%.

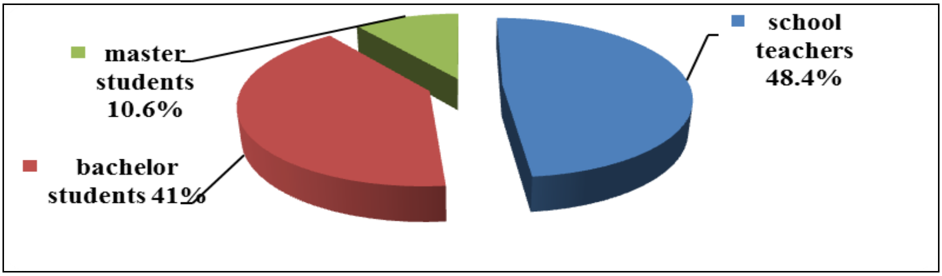

Figure 1. Qualification category of specialists
Source: Own work

The questioning involved the students, who are just starting their professional activity (work experience up to a year – 10.6% of the respondents), and with a short work experience (from 1 year to 5 years – 7.5%, from 5 to 10 years – 13.6%) and specialists with more than 10 years of professional experience (27.3%) (Figure 2). Assessing the need of training (Figure 3), improvement of the professional skills during all life, 57.5% of the respondents are interested in the continuous professional development. They believe that teachers who provide training, should be aware of modern pedagogical trends, maintain their pedagogical competence at the required level, constantly improving their pedagogical skills, which will make it possible to increase the effectiveness of training.

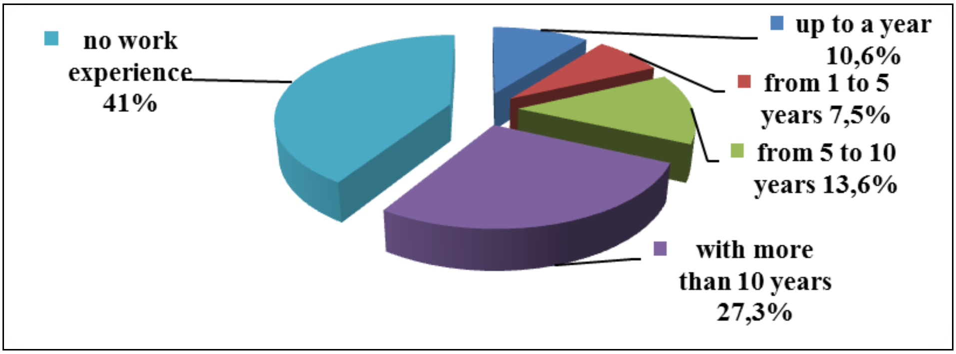

Figure 2. Work experience
Source: Own work

As for active teaching methods (training, research projects, problem tasks of an interdisciplinary nature), 71% of the respondents note that in the process of modern education they should prevail. The questionnaire also offered the questions on identifying the pedagogical competence of a modern teacher.

The answers of the respondents show that they consider an ideal mathematics teacher to be a highly qualified practitioner with excellent theoretical background, able to combine theory and practice, use modern pedagogical technologies, apply advanced information and computer technologies. Answering the questions about STEM education, the respondents gave the following results: 25.2% of the respondents had an idea about this technology, 27% attended conferences and seminars on STEM education. Most of them were teachers and only 5% were students.

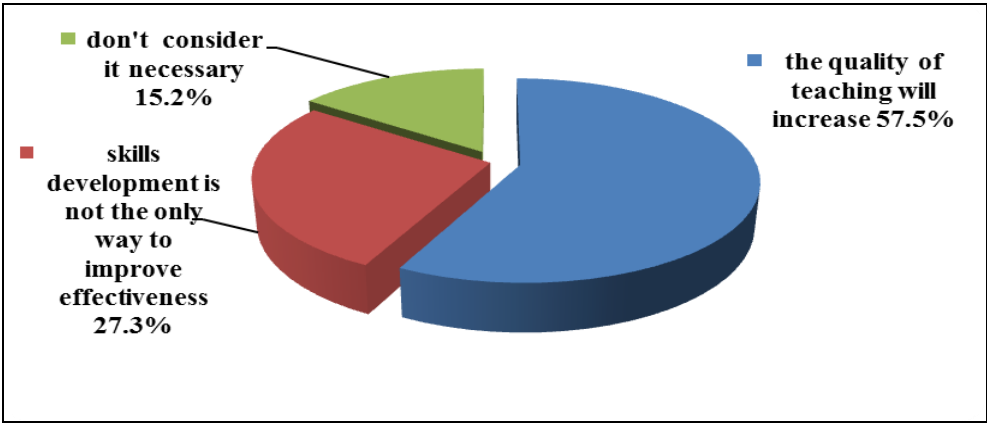

Figure 3. The need for continuous skills development of teachers
Source: Own work

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Among the online resources that can be used in STEM education the following were mentioned: interactive boards, electronic textbooks, educational software, own designs of tables, figures for geometric and textual tasks, simulators for controlling computational skills. 12% of the respondents use the interactive whiteboard actively, 17% use programs for creating dynamic models of geometric shapes and graphs, 15% apply their own electronic design to the lessons. Unfortunately, these results show only practicing teachers.

From the listed STEM education tools (EV3 Programming, GeoGebra Classic, GeoGebra Graphing Calculator, GeoGebra Geometry, Sensavis Visual Learning Tool, Polyup, FMath, MyBookMachine Player, FluidMath, EquatIO, Matific), only 6% of the interviewed teachers used GeoGebra Geometry in their practice, 17.6% of students worked in the classroom with GeoGebra Geometry, 3% with Polyup.

It should be noted that 7.5% of the respondents had special vocational training for the realization of innovations in education, all of them from among the students, studying in the specialty 014. Secondary education. Computer science. Answering the question about the professional position on information technologies and their application in the educational process, 16.7% think that this is a distant future, 36.3% answered that nothing will change, since there are no conditions for their use, 27% are interested in new software tools and find their use useful in solving interdisciplinary tasks. (Figure 4)

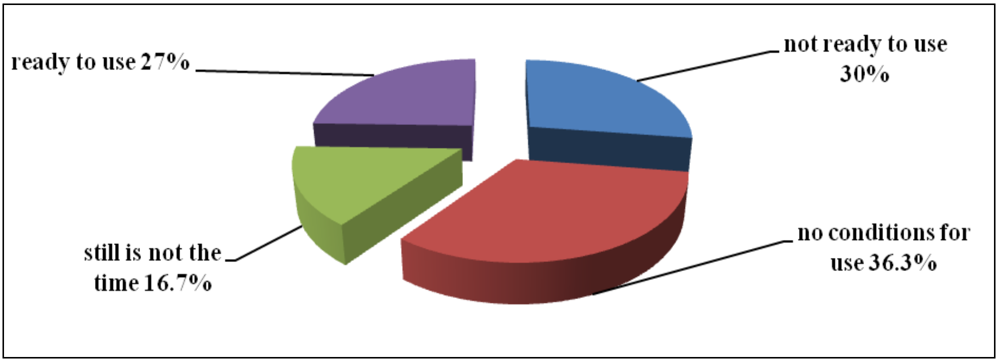

Figure 4. Readiness for use of IT technologies
Source: Own work

CONCLUSION

In our opinion, the lack of motivation for innovative activity among teachers, problems with technical equipment at educational institutions is the reason for obtaining such research results. The interviewed respondents think that the most effective form of classroom work is practical exercises with the use of modern educational technologies, web resources, simulators, and project activities. Independent classroom work, in their opinion, should include self-learning material for further discussion with the teacher (43% of the respondents) and independent work on doing the individual practical tasks and projects (29% of the respondents). Their views on STEM education state that they see the advantages and effectiveness of STEM education compared to other technologies, at the same time the majority (87%) stated the need to have special courses to master the STEM training method. Summarizing the aforesaid, it can be noted that the formation of teachers' readiness for using modern educational technologies, namely STEM education, should be carried out, starting from pedagogical universities, specially and purposefully in the process of studying psychological, pedagogical and special disciplines and special courses, focused on learning the basics of STEM training. It is advisable to adopt foreign experience of special training, to introduce new subjects. The teachers should monitor fast-growing scientific and technological innovations. Their role is not to transfer theoretical knowledge to school students in science lessons, technology, engineering and mathematics, but to raise their level of thinking to a high level, so that the school students were ready to learn throughout their lives. The implementation of STEM education in our country should be aimed at ensuring that students, future teachers of mathematics, acting teachers develop their abilities to research, solve methodological problems and develop products with an interdisciplinary view of mathematical disciplines, and are ready to work with STEM teaching tools.

Our further research will be devoted to studying the practical application of STEM tools in the educational and research activities of students of pedagogical universities.

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IMPACT OF CHANGES IN TEACHING COMPUTER SCIENCE IN UKRAINIAN SCHOOLS ON FORMING THE CONTENT OF COMPUTER SCIENCE COURSES AT NON-CORE SPECIALTIES IN UNIVERSITIES

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Abstract: *The article deals with the problem of forming the content of computer science courses at non-core specialties in higher education institutions due to the changes in teaching computer science in Ukrainian schools. Some existing approaches to modernization of computer sciense higher education are considered. The attitudes of students who study at different curricula, to computer science education are analyzed. Possible ways of modernization of computer science courses at non-core university specialties are offered on the basis of psychological characteristics of secondary and higher school students and current social needs.*

Key words: computer science, educational content, non-core specialties.

INTRODUCTION

The problem of teaching non-core disciplines for various specialties in higher education institutions is constantly at the center of attention of teachers, scholars, methodologists working in higher education. In particular, the teaching of computer science, information technology at non-core specialties has certain problems as well, firstly in the educational content (Korol, Alekseev, 2014). There are many reasons for this, among that the following should be noted:

– as a rule, the planning of training time, schedule of classes, workload of laboratories for non-core disciplines is carried out according to the "residual" principle;

- thereby, in conditions of a relatively small amount of academic time, it is necessary to have time to consider the basic concepts of the discipline and to form students with the appropriate competences;
- students do not pay sufficient attention to the deep absorption of non-core disciplines, because they consider them not to be important for their professional training.

Under such conditions, the teacher first of all needs to build the content of the training course so that the student is not only interested in learning the subject, but also is able to acquire the maximum amount of relevant competences in limited time. The solution of this problem requires careful construction of the course content, taking into account the psychological characteristics of students of correspondent age.

RESEARCH METHODOLODGY

The methodological basis of the research is the systematic scientific and methodological analysis of the problem, which was conducted through the study of school and university curricula, questionnaires for students of high and secondary schools, the processing of scientific articles, publications in the pedagogical and psychological press, regulatory documents and study of the experience of leading specialists in the field of psychology and teachers of computer science and methods of teaching computer science.

The means of the study are structurally-logical analysis of the state of the problem and possible ways of modernization of courses of computer science at non-core university specialties, corresponding to the problem.

For solving the research problem, system-analytical and constructive approaches were used that allowed to optimize the course of research.

1. PSYCHOLOGICAL PECULIARITIES OF STUDENTS IN THE TRANSITION FROM SCHOOL TO UNIVERSITY EDUCATION

Early adolescence is characterized by ambiguity in the definition of the concept of leading activity. The most common is the point of view, according to which the leading activity is intimate-personal communication. In other words, meeting the need for communication and moral support are the most important needs of the student's personality. Intimate-person communication with peers becomes an important channel for the information transfer that is important for children development. It helps to satisfy the need for knowledge of those spheres of reality that are interesting for children and for some reason are not satisfied with adults. That is why computers and the Internet are increasingly part of everyday life of students, enabling them to solve the difficulties that arose at a certain stage of socialization.

So, with the help of social networks, students meet hidden needs that are not followed in their real life, but only in dreams or fantasies.

The transition from school to student life is accompanied by such a psychological criterion as a sharp change in the internal position and a change in attitudes towards the future. If the student looks at the future from the position of the present, then the student looks at the present from the position of the future. The main orientation of the person changes, and now it is manifested in the pursuit of the future, determining the future life path and the choice of profession.

In student years, there is a fundamentally important change in the views on the future, because now the subject of deliberation is not only the end result, but also the ways and means of achieving it.

One of the important tasks of professional training in almost all specialties is to adapt the person to professional activity in the conditions of information society. A graduate of a higher education institution must not only possess a certain amount of knowledge, but must also learn to adapt in the conditions of rapid change of generations of technologies.

The problem of research into the motivation of students to study computer science is considered in the work (Mladenović, Žankob, Mladenović, 2014).

According to the authors, despite the need to study computer sciences for improving literacy, with the goal of free possession of information technology and despite the growing requirements for specialists in the field of computer science, the motivation for studying computer disciplines at all levels of education is reduced.

Statistics showed that external motives are dominant motivations, that is confirmed by data of studies from other countries. Hence, this shows that students are not internally motivated to study courses in computer science.

The study (Hilty, Huber, 2018) allows determining what factors can motivate students studying information and communication technologies within the framework of the project of sustainable development of society. The main conclusion is that it is worth focusing on the impact of the learning environment on student motivation.

However, it should be taken into account that no matter what the learning environment is, the student can't be motivated to study the course, if the course content is already well known to him or does not correspond to his future professional activity.

Thus, it is necessary to create conditions for the formation of a new social stratum, the basis of which will be specialists who mastered computer technologies and form the intellectual market. And this will ensure the continuous circulation of new intellectual communication in the field of production and public life. Experts with a high level of computer training are becoming more and more competitive in the labour market. One of the main requirements for a qualified specialist today is the skillful use of modern information technologies.

2. ANALYSIS OF THE CURRENT STATE OF COMPUTER SCIENCE EDUCATION IN SCHOOLS AND NON-CORE SPECIALTIES OF THE UNIVERSITY

In addition to the motivational factors, the basic set of knowledge and relevant competences that a student received during the study of the school course of this or related discipline influences the formation of the content of the discipline. At the same time, the level of these competences should be sufficient for the mastery of a university course. Such a set in Ukraine is determined by the State standard of basic and complete secondary education. When changing the state standard, the main components of the methodical system of teaching a school course of a certain discipline, as well as corresponding university courses, should change.

It should be noted that at present Ukrainian entrants are mostly studying under the Standard of 2004, which, in our opinion, does not correspond to modern realities. School graduates have different basic training at computer science,

which is influenced by several factors, in particular:

- impossibility to comprehensively cover the entire spectrum of issues of modern computer science in a short time of the discipline studying ;
- availability of several different curricula and significant differences between them;
- difference between the level of preparation of the urban and rural entrants;
- problems with the provision of schools with a sufficient number of modern computers with Internet connection and multimedia equipment;
- conformity of computer equipment and software to modern requirements;
- the main goals of using modern computer technologies at home etc.

Consequently, we can state that at present, a graduate of a school, who must have a set of basic information competences, in many cases has significant gaps in knowledge and skills, that does not correspond to the current state of development of computer science and society.

Until now, one of the main tasks facing the teacher of higher school in the field of computer science was to initially form the student with a minimum level of basic training in computer science, eliminate gaps in the study of the school computer science course, and then develop competences that are specific to the specialty chosen by the student. As a rule, it required the inclusion in the university course of computer science of the following list of topics:

- fundamental basics of computer science (information, coding, algorithmization, etc.);
- electronic document flow (based on one of the "office" packages);
- use of the computer network in educational and professional activities;
- use of specialized software, including applications for support future professional activities.

As a result, the study of additional subjects or deeper familiarization with such topics was substantially complicated due to the limited training time allocated to the course.

It should be noted that attempts to include in the course of computer science for non-core specialties specific questions of profile information disciplines, for example, programming, system administration, computer architecture etc did not lead to deepening students' knowledge, but to their negative attitude to the course and reduction of motivation to study.

However, with the introduction in Ukraine of the State Standard of Basic and Complete Secondary Education (Resolution of the Cabinet of Ministers of Ukraine dated November 23, 2011 No. 1392, 2011), from 2012 the situation with the teaching of computer science at non-core specialties of higher education institutions should radically change. If at the present time university entrants are those who mainly studied computer science only the last two years of study, then in 2020 in universities will come students, who studied computer science from the fifth grade of school for seven years, and three years later - those who studied computer science almost the entire period of school study (Programme of Informatics courses 5-9 classes of general educational institutions, 2017).

So there is a problem of modernizing the content of computer science courses in higher education institutions. Considering that at the moment the list of topics and the number of academic hours devoted to them at the minimum amount of the school program significantly exceeds the content of the course of computer science at most non-core specialties, then there is the question: what transformations are waiting for a course of computer science for non-core specialties, and what should become the content of this course?

3. SOME EXISTING APPROACHES TO THE MODERNIZATION OF INFORMATICS EDUCATION AT UNIVERSITIES

The analysis of professional literature shows that the realities of today require the modernization of all spheres of life, and, consequently, education, not only in Ukraine, but also in other countries. Almost all aspects of the learning process need to update, in particular:

- the composition of general and professional competences that students of a secondary and a higher school need to acquire in the learning process;
- content of educational courses and the methodical approaches to their teaching;
- hardware and software that should meet the purpose, content and methods of learning.

As one of the approaches to solving these problems, scientists see the transition from a traditional higher education institution to the concept of a modern, so-called smart university.

In the research (Smyrnova-Trybulska, 2018) the main components of a smart university are analyzed:

- Hardware/Equipment devices (e.g. Panoramic video cameras, SMART boards and/or interactive white boards, etc.);
- Smart curricula (e.g. Adaptive programmes of study, Adaptive courses (with various types of teaching form: face-to-face, blended, online);
- Student, lecturers, administration (e.g.: Blended or fully Online, Lifelong learners (retired) in open education);
- Smart pedagogy (e.g. Collaborative teaching-learning, Learning-by-doing, Adaptive teaching-learning, Flipped classroom);
- Smart Classroom (e.g. Smart classrooms with corresponding technologies. Software hardware systems. Smart pedagogy for smart education);
- Technologies (e.g. cloud computing technology, 3D visualization technology);
- Software systems (e.g. Web-lecturing systems, Systems for seamless collaborative learning).

Authors of the research (Kołodziejczak, Mokwa-Tarnowska, Roszak, 2018) identify the following trends in the application of modern technology in higher education and analyze the barriers to their implementation in Polish universities:

- Mobile learning (m-learning);
- 1.2 Multimedia learning;
- E-textbooks;
- Web 2.0 tools-based learning;

- Virtual Reality (VR);
- Augmented Reality (AR);
- Mixed Reality (MR).

In the work (Makasiranondh, Maj, Veal, 2011) the process of forming some common skills (soft skills) of Australian students during the study of IT courses is researched. The authors focused on competences such as communication skills, leadership skills, and teamwork skills. It is proposed to develop these skills in practical activities through joint projects.

In (Nager, Atkinson, 2016) it is noted that in modern conditions, when the role of STEM education is growing, modernization of computer science education is of particular importance. The introduction of teaching information technology, adequate to modern challenges, in the training of specialists of different profiles, "ensures that students are competitive and adaptable in the labour market, not just for jobs in computer science, but for many occupations that increasingly require "double-deep" skills".

The studies under consideration are mainly about the general directions of modernization of education, change of methods, means, organizational forms of training, but the purpose of our research is precisely the change of content, on which we are focused.

The content of information education at non-core specialties in Ukraine has been considered by various authors, including (Olifirov, Makoveichuk, 2013), (Korol, 2014), but due to the implementation of the new State Education Standard, the results of these studies have already lost some relevance.

4. ANALYSIS OF STUDENTS' OPINIONS REGARDING COMPUTER SCIENCE EDUCATION

For a more reasoned definition of the directions of modernization of the computer science course for non-core specialties, a questionnaire was conducted for students of grades 10 and 11 of schools in Chernihiv. Totally 298 students were polled, where 145 – of grade 10, 153 – of grade 11. The choice of students of grades 10 and 11 is due to the following factors. Grade 11 students, like current university students, have studied computer science at school for only 2-3 years, so the current state of content of the computer science course of higher education institutions is oriented precisely at such students. At the same time 10 grade students have already studied computer science at school for 7-10 years, accordingly, a significant number of topics that make up the modern university curriculum are out of date for them. Therefore, the content of the correspondent university courses requires adjustment. The purpose of the survey was:

- to determine the fields of use of computer technology by students;

- to determine trust in the data found on the Internet and its verification in other sources;
- to identify the state of use of Internet technologies for training;
- to identify ways to improve the study of computer science at school from the students' point of view;
- to identify the topics that, in the eyes of the students, are superfluous for studying and the topics that are lacking in the school's computer science course.

The results of the survey show that the main goals of using computer technology by students in general do not depend on the level of basic training in computer science (Table 1). Nevertheless, one can see that students of the 10th grade use a computer for gaming and social networking somewhat less.

Table 1

Using computer technology by students

Answer option	**Grade 10 (in %)**	**Grade 11 (in %)**
Watching videos / listening to music	91	83
Viewing news and social networking	47	62
Playing games	24	40
Study	84	79
Earnings	7	4

Source: Own work

It should be noted that when answering the question "Have there been any topics in the course of school computer science that contributed to you doing better in other disciplines?" a significant number of students of the 11th grade gave a negative answer or did not answer at all. This indirectly confirms the thesis on the inadequate level of formation of basic information competences of such students. At the same time, students of the 10th grade mostly answered affirmatively (often mentioning office software), which indicates a higher level of computer literacy than students of the 11th grade.

The answers of students of the 10th and 11th grades to the questions "What topics, in your opinion, would be necessary to add to the course of computer science?" and "What topics of the course of computer science you consider superfluous to study at school?" also differed.

In particular, 18% of the 11th grade students believe that programming is the lacked topic in the course of computer science, and 18% state the same about the computer graphics and multimedia. At the same time, 10-grade students in general indicate that new topics are not needed, but 37% of the polled students indicate that in the school curriculum there is not enough computer graphics and multimedia, and 18% - issues related to the Internet.

On the other hand, among the 11th grade students, the overwhelming majority believes that in the school curriculum are no superfluous to study topics and the opinions of the rest are significantly different. At the same time, 34% of 10th grade students find it superfluous to study the basics of programming.

Indicative is the divergence in the attitude of students to the study of programming: if a sufficient number of students in 11 grades (where programming is not studied) believes that programming is lacked in the course of computer science, then one third of students in the 10th grade, where programming is a required component of the course of computer science, considers it superfluous. Mostly, these are the students who relate their future to studying in higher education institutions in the humanities. This once again confirms the opinion that the study of this topic on non-core specialties is superfluous.

Among the topics that require more thorough study, one should also note the problem of searching for data on the Internet and their subsequent analysis. So answering the question "To what extent do you trust the information received through the Internet", most students in the 10th and 11th grades claimed that they trusted only reliable, in their opinion sources, and checked information from other sources (Table 2). However, the determination of the reliability of the sources varies widely and is sometimes ungrounded.

Table 2

The level of trust in the information received through the Internet

Answer option	**Grade 10 (in %)**	**Grade 11 (in %)**
I do not trust at all	4	2
I only trust reliable, in my opinion, sources. I do not trust others	24	21
I only trust reliable, in my opinion, sources. I check information from other sources	56	57
Check information from any source	16	21
I trust everything	0	0

Source: Own work

However, as regards the verification of information found on the Internet, students of the 10th grade are less trustful (Table 3). This can be explained by a higher level of basic information competences and a wider range of learned topics.

Table 3

Verification of information found on the Internet

Answer option	Grade 10 (in %)	Grade 11 (in %)
I do not check at all	9	6
I check in one or two other sources	69	83
I check in three or more other sources	22	11

Source: Own work

Teachers of higher education institutions also mark the inadequate level of students' skills in the search, analysis and processing data of their subject area, in particular statistical and experimental data.

Therefore, gaining students' competence in the search for information, critical attitude towards it, analysis and processing of the findings should be the subject of a more thorough approach not only at school but also in higher education institutions.

Indicative are the results of a survey on the use of Internet technologies for self-education. All interviewed students indicated that they use video tutorials for self-education - 78%, social networking groups - 58%, online courses - 44% (Figure 1). This shows that students have a certain degree of readiness to independently raise their level of learning. However, there is a need for additional attention to the use of online courses, especially given the current challenges in terms of readiness for training and raising the professional level of the future specialist throughout his life.

The students note, however, that a large number of e-courses they have applied for or would like to use have an English interface. For students who are poor in English, this is a significant problem, partially solved by specialized software such as machine translation systems.

Unfortunately, the work with the systems of machine and automated translation at school and university is practically not considered, although some researchers note the importance of their study, especially for students of non-linguistic specialties (Romaniuk, 2017).

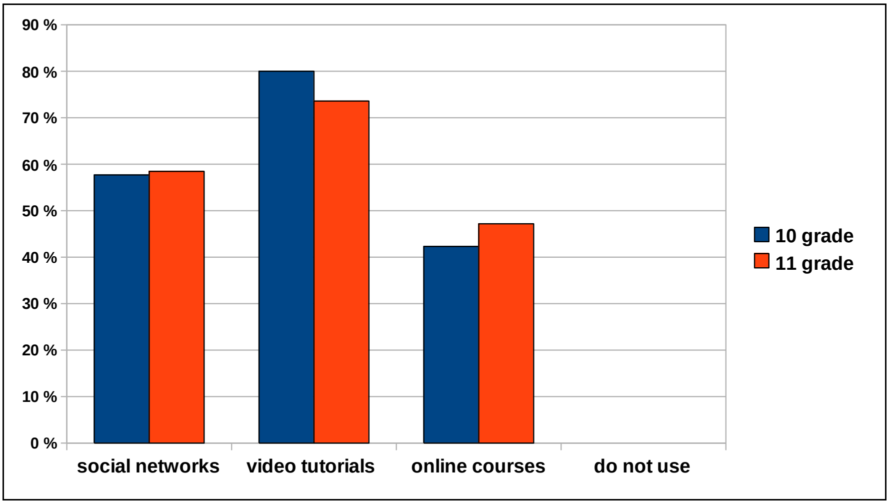

Figure 1. Usage of Internet technologies for self-education
Source: Own work

During the interview, students were also asked to speak about factors that could, in their opinion, improve the study of computer science at school (Figure 2, Figure 3).

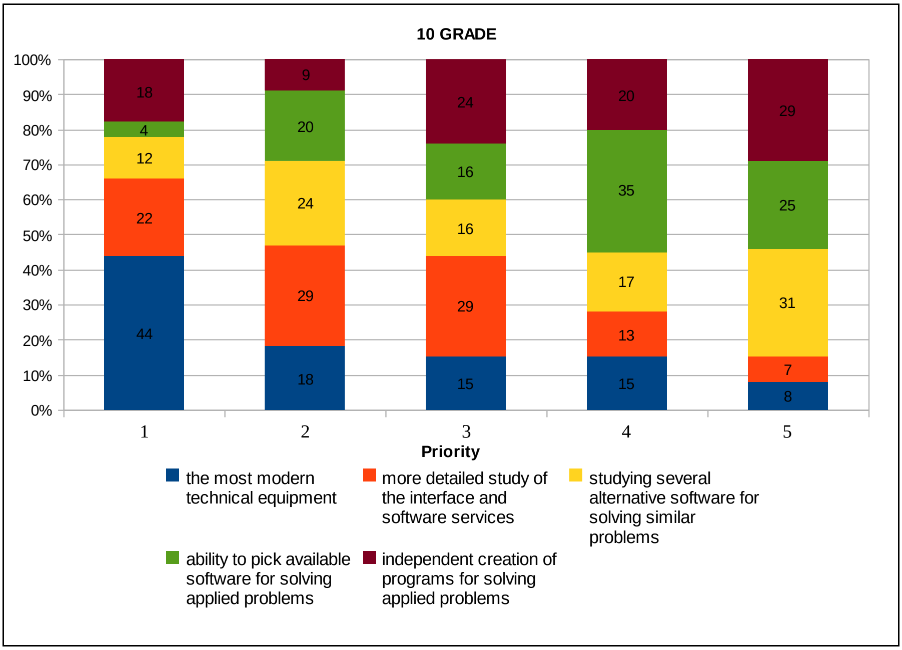

Figure 2. Distribution of priorities of factors that could improve the study of computer science at school by 10 grade students. Priority 1 (highest impact), 5 (lowest impact)
Source: Own work

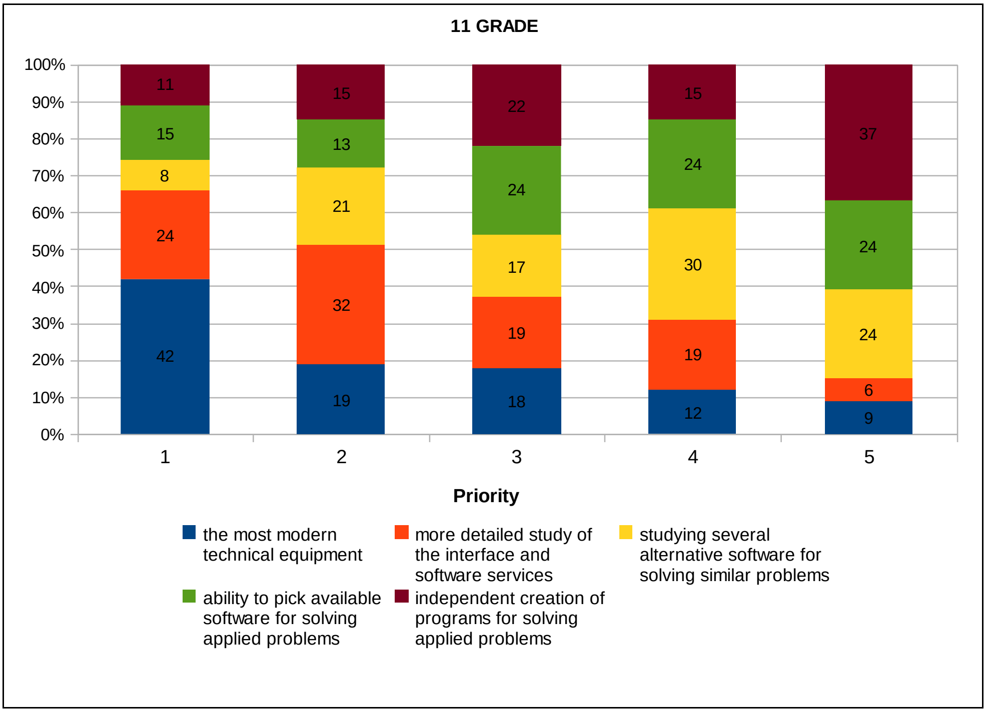

Figure 3. Distribution of priorities of factors that could improve the study of computer science at school by 11 grade students. Priority 1 (highest impact), 5 (lowest impact)

Source: Own work

From the diagrams, we can see that the students of both the 10th and the 11th grades consider the supply of schools with modern equipment the most important factor that can contribute to the improvement of the study of computer science at school. This may indicate a desire to be on the wave of technological progress and use more modern computer technology and software.

Indeed, the use of modern hardware and software contributes to the most effective implementation of STEM education principles in the educational process. It is well known that STEM education is based on simple and accessible visualization of scientific phenomena, which makes it easy to capture and gain knowledge through practice. Therefore, in our opinion, this approach is relevant in the study of computer science for non-professional specialties and should be the basis for the study of most computer science disciplines.

On the other hand, a significant problem, in our opinion, is students' underestimation of the problem of the ability to pick available software for solving applied problems. If for a school graduate the formation of such skills is not critical, then for the future specialist in any field, such skills are important, therefore, this problem should be one of the basic issues in shaping the content of the computer science course in universities.

Taking into account many years of teaching experience and research by authors (Horoshko, Tsybko, 2017), one of the ways of effective selection of available software for solving applied problems arising in the learning and professional activity is the widespread use of freely distributed software.

CONCLUSION

Thus, summing up, in our opinion, one of the options for modernization of the training course in computer science for non-core specialties of higher education institutions in Ukraine may be the following list of proposals:

- reduction of academic time to study the fundamental basics of the course of computer science, that are now quite thoroughly considered in the school curriculum;
- exclusion of topics that do not directly relate to the formation of professional information competences (programming, computer architecture, etc.);
- increase of academic time for studying the problems of using electronic document circulation in future professional activity by reducing the time to study the basic principles of work with certain "office" packages;
- improving the skills of finding information on the Internet and developing more profound skills to critically evaluate this information;
- study of activity environments and information systems that can be used in future professional activities;
- studying the analysis and processing of the subject field, specific for the student's specialty, including experimental ones;
- familiarization with the elements of computer simulation for the construction of information models relevant to professional activities, with the help of well-selected specialized software;
- familiarization with e-learning systems as not only the user but also the author of electronic courses (for students who associate their future professional activities with teaching or research);
- acquaintance with computer-aided translation programs and electronic dictionaries for the development of competences in working with foreign scientific texts relevant to professional activities;
- wide involvement in the educational process freely distributed software to prevent the illegitime use of proprietary software;

– use of mobile platforms and applications in future activities.

It should be noted that the course of computer science for non-core specialties with these changes should be implemented on the basis of widespread use of e-learning systems, which will ensure its compliance with modern requirements, namely: the ability to build an individual trajectory of learning, implementation of the idea of lifelong learning, ensuring inclusiveness of education.

In addition, there is a necessity to require using information technology elements from the field of future professional activity when writing qualifying papers in a specialty in order to increase the level of professional training of a future specialist.

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CHAPTER V: HUMANITIES, SOCIAL AND SCIENTIFIC POTENTIAL OF E-LEARNING AND STEM EDUCATION

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THE PROJECT "INCLUSIVE CLASSROOM-PLAY AND LEARN - CONCEPTION, DESIGN AND SOFTWARE ARCHITECTURE"

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***Abstract**: The article presents an ongoing research project aiming to produce an innovative educational application for mobile devices, addressed to students with special educational needs, their teachers and parents. The software architecture including intelligent assistant and the process of conception, design and implementation of the App is described. The focus of the methodology is to provide a child centered approach to learning considering an individual's interests, cognitive ability, strengths and challenges. The app consists of games and resources supporting development of skills to process information, problem solving, planning and organizing, and expanding knowledge about science objects and phenomena, ecology, human body and health.*

Keywords: mobile educational app, inclusive education, intelligent assistant, SEN students

INTRODUCTION

The recent policy of Bulgarian Ministry of Education promotes comprehensive implementation of electronic educational platforms and resources at all schools and centers for personal support and development. Investment in ICT and digital resources and implementation of new policies and good practices in the area of inclusive education for SEN (Special Educational Needs) students, aims to provide equal access and quality of education to all students. Special needs is a broad term that encompasses children who have physical, emotional and/or intellectual disabilities, causing learning difficulties. These children may need help in a variety of areas depending upon their conditions and a range of needs. Special needs typically address at least some or all the following: academic assistance, help with language/verbal skills, help relating to others, behavior management, organizational skills, sensory needs and/ or physical assistance.

The article presents project in progress targeting to design an innovative educational application for mobile devices, addressed to students with special educational needs, their teachers and parents. The language of instruction is Bulgarian.

1. BACKGROUND AND ARGUMENTATION

Smart mobile digital devices represent a new generation of technological tools that offer phenomenal access to content as well as opportunities for creative use by users belong to any age and ability groups. A key reason for the popularity of smart mobile devices is related to technological features of these devices as large screen displays, high resolution, lightweight, user-friendly and ergonomic design, short start-up time and multimedia content viewing ability (Papadakis et al., 2016). The same author concludes that while there are thousands of apps available today, choosing the most appropriate educational ones for children is difficult and problematic for both teachers and educators. (Papadakis et al., 2017).

A very specific feature of devices is undrained by Perez ″The device enjoys a high degree of social acceptability that appeals to students and parents. With the iPad and similar consumer devices, individuals with special needs are using the same technology as their peers. The importance of this dimension cannot be underestimated, as it can dramatically impact the level of device use.″ (Perez, 2018)

A theoretical background of the methodology of this project design is constructivist theory. The key points in constructivism are given by the direct link between learning and experience, by the active role of learners in constructing knowledge for themselves and by the application of knowledge onto realistic problems to solve. The best way of implementing the constructivist approach is to embed the learning content into the context; the learner has to actively deal with it to advance in the game. (Catalano, 2014) The learner builds his/her knowledge actively, opposite to get them as a ready product taught by the educator. To learn constructively means to learn actively, to develop skills to transfer what is learned by solving a variety of authentic tasks. The learning process flow in a stimulating environment with focus on acquisition of personal experience, meaning and encouraging critical thinking.

Information was gathered about available Apps for SEN students, and the use of some specific applications with people having various conditions was studied. The research includes materials presented in English and Bulgarian languages.

According to Cohen et al. (2011, p.9) the 'world of apps' currently designed for children includes three general types: gaming apps, creating apps and e-books.

- In gaming apps, the activity includes a range of challenges, actions and reactions that lead to skill acquisition and achievement as levels are played and mastered.
- In reading apps or e-books, the story or the reading of the story is the activity. Playful features or mini activities are integrated into a familiar schema of reading a book. The curriculum is in this context either explicit in the text or implicit and embedded in the activities.
- Creating apps provide tools, workspace and activities (e.g. robots, painting, etc.).

Our project subsumes games targeting skills as planning, organization, task initiation, time management, following directions, sequencing, working memory, self-control, attention, taking turns, flexibility and perseverance. The target age group is 2 to 12-year-old people with ASD (Autistic Spectrum Disorder), ID (Intellectual disability) and some other conditions that may prevent students from learning in inclusive educational settings. In order to benefit from the motivational potential of games we used a "gamification" approach. The application design consists of various games for students and information for parents and teachers.

A variety of Apps for SEN students are available in English language. The apps are classified according to their purposes: communication (e.g. Go Talk, Talk Board), acquisition of digital content as music, video, stories (e.g. Kids videos, Niki Music, Do2Learn), learning by playing (e.g. Professor Garfield, Math Square), apps for time management and daily schedules (e.g. Tiimo, Magnus Cards, My Video Schedule). Many of the Apps are created to support learning in content areas such as writing, mathematics, logic, science or develop sensory, digital and other skills. Unfortunately, it is not possible to use them in inclusive classroom settings or special centers for personal support and development because the language of instruction is not Bulgarian.

Our research shows that for SEN students there are few digital applications, portals and software using Bulgarian language. The application Together at school is created especially for SEN students and is a good example of the description of the software, design and links to the educational purposes laid in. The domains contain mathematics, reading and logic. Comprehensive information, links, educational methodology and study tasks are well presented in special portal Dyslexic children. It is interactive and provides educators and parents with latest news on training and educational materials and varied tasks for students as well. Another useful software translated in Bulgarian language is Tobii Dynavox Communicator 5 intended to support and help people with communication difficulties to reach a better level of independency. This software offers three main groups of applications: emerging communication, symbol communication and text communication. The special feature in this software is the possibility for the educators to use different languages of instruction including Bulgarian and to modify the content, task and other features in the program. This software offers possibility for eye control, which makes it useful for students with limited mobility.

From the research targeting to inform the conception, design and development of our project named ″INCLUSIVE CLASSROOM-PLAY AND LEARN‵ we may conclude that good examples coexist and at the same time there is necessity to create and implement a specially designed digital educational application for SEN students with Bulgarian as a language of instruction and domains: ecology, human body and health as science objects and phenomena. The app is targeted for differentiation, personalization and additional support for students with special educational needs educated in inclusive classroom settings.

2. GAME-BASED LEARNING ENVIRONMENT

Figure 1. presents the general architecture of the game-based learning environment. The core of the environment is a multi-agent system that includes two types of assistant, implemented as intelligent agents.

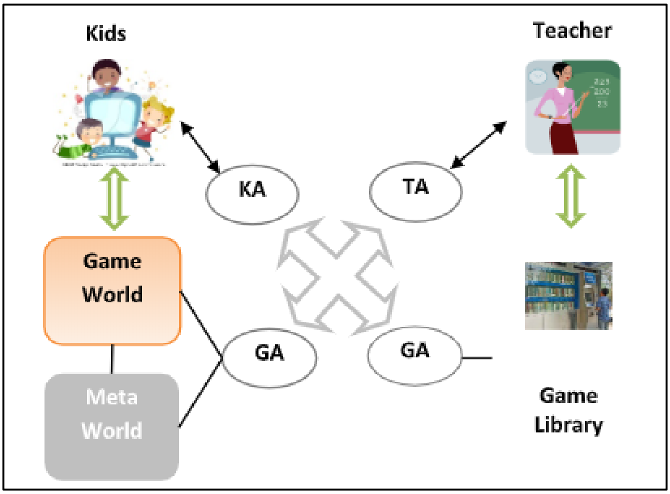

Figure 1. General scheme of gaming-based learning

Source: Our work

The first type is the so-called personal assistant (PA), the purpose of which is to support the work of users (children, students, teachers) within the environment. Primarily, PA assists two user groups - gamers (children, students) and evaluating game results (teachers).

The second type is the so-called Operational Assistants (OA). Typically, these are server agents that provide the game. OAs are transparent to gamers. Basic OA is the game assistant (GA), which implements the logic, management and control of the game. In addition, GA can, individually for each player, collect different information about the course of the game, the result and the chosen approach. This information is accessible to the teacher's personal assistant, who can plan appropriate corrective actions. Other Operations Assistants serve a Game Library.

The environment of operational assistants includes the following three basic components:

– **Game World -** Virtual 3D or 2D world, visible and accessible to players. It activates the currently selected learning game.

– **Meta World -** This storage, transparent to the players, stores information that is not directly related to the content of the game. Data recorded in Meta World can be considered as a specific protocol that reflects the course of the game, including the reactions and mistakes of the players. This protocol can be used for later personal analysis of the game.

– **Game Library** - This is a game storage where OPs can choose and activate the game in Game World. The games are divided into three main categories - for beginners, for experienced and for advanced players.

2.1 Game play lifecycle in the above environment

– **Game suggestion -** depending on the teacher's requirements (via his / hers) OA defines the games that can be activated by the players in the next game session. The list of possible games is presented to the Game World player.

– **Game choice -** the player chooses a desired game (from the supply). OA registers the player's desire, selects from the Game menu and activates it in Game World.

– **Game play -** During the game, the GA collects data that will serve to evaluate the achievement of the player. When circumstances arise, such as need for help (if acceptable), violation of game rules, completion or inability to continue the game, GA is activated (proactive).

– **Game completion and assessment -** GA evaluates the player's performance (achievement), announces it to the player, and records the achievement in Meta World where they are available to the teacher for subsequent evaluation.

The assistants are realized as intelligent BDI (Belief-Desire-Intention) agents (Rao, 1995) using a model of human activity where:

- **Beliefs -** the effect of the acting student's actions.
- **Desires -** generated depending on the game. There may be different conditions where the agent should intervene in the game (become proactive).
- **Intentions** – depending on the case, one of the desires is transformed into a goal. The goal determines what the agent should do.

2.2 Game World

First, we will look at a game considered to be played by advanced players. Figure 2. presents the three main software components in a Game World prototype developed by the authors.

- **Web Administration -** Used by Admins and Teachers.
- **Graphics Editor -** Used by Admins.
- **Client side - Web & Mobile -** Used by students.

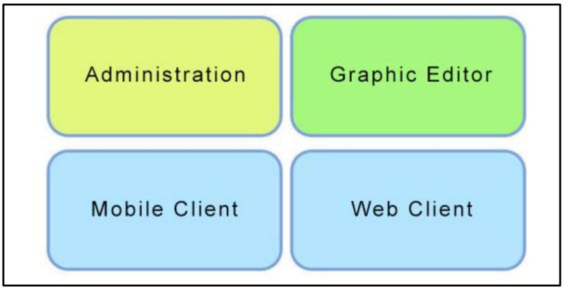

Figure 2. Software components in Game World
Source: Our work

2.2.1 Web Administration

Web administration is used by Teachers. Built with Vue.js - a modern JavaScript framework for building component-based web applications. In the administrative part, teachers have the opportunity to add new students, create exams or edit existing ones, and check the test results of the players (Figure 3).

2.2.2 Graphics Editor

The graphics editor is used by administrators. Built with Backbone.js framework and altered to create software agents environment. The Graphics Editor is designed to easily create different types of virtual worlds in which the student plays. It provides the opportunity to create random worlds, edit existing ones and save them. The graphics editor mechanism allows the user to add countless multiple objects as long as each of them is accompanied by a matching graphical resource.

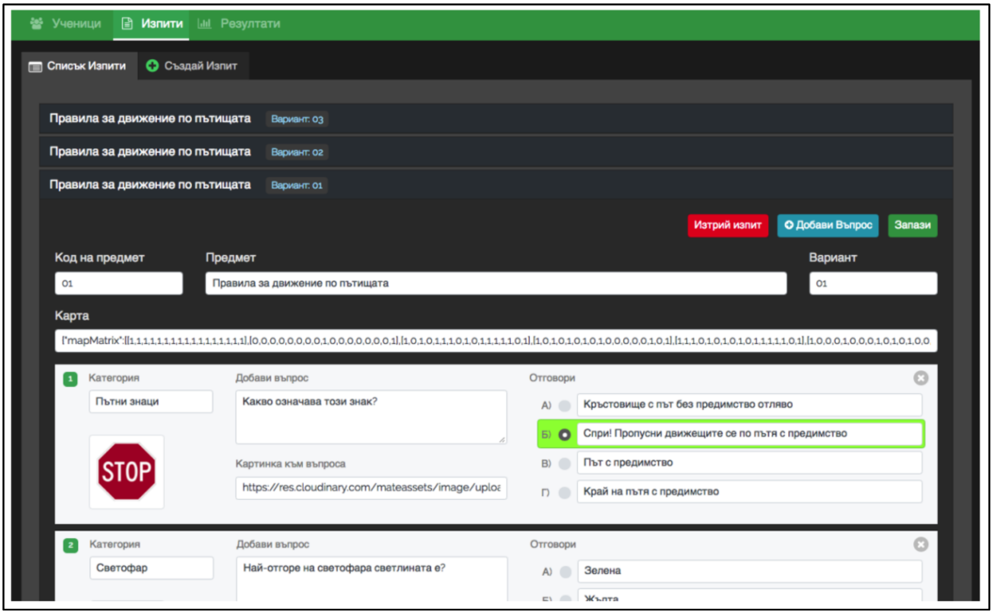

Figure 3. Web Administration - editing an existing exam
Source: Our work

Figure 4. Graphics Editor - Map Creation (Exam)
Source: Our work

At present, 17 types of buildings and 20 types of traffic signs and traffic lights have been created, which the authors consider necessary to create a variety of maps covering the general cases and the matter studied by students in the field of Road Safety.

Figure 4. shows the creation of a game map matching a specific exam created within the **Web Administration**, which will be delivered to the students in the game environment.

2.2.3 Client Side - Web

That module is used by students. It is built using Backbone.js framework and is distributed as a browser application. The gameplay follows the cycle: First the student selects his profile, then selects a map (exam) and after that he has to move turn by turn in the provided virtual world (Figure 5). At each turn, the student moves forward by answering questions from the predefined categories corresponding to the virtual traffic situation in which he is located. At the end of the exam, the player receives a message of successful completion and a result of his game.

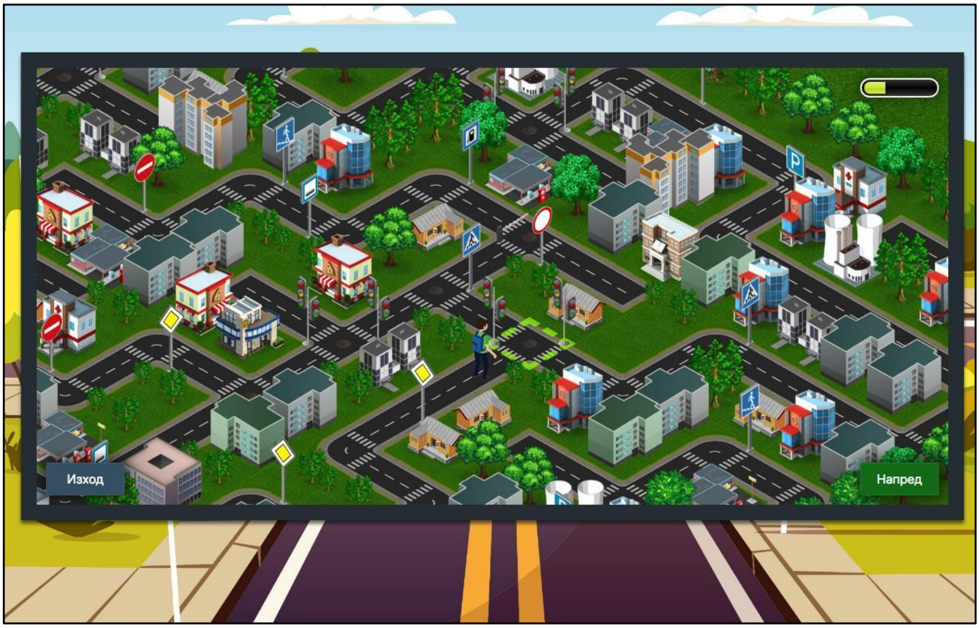

Figure 5. Client Side - Web
Source: Our work

2.2.4 Client Side - Mobile

The mobile client side environment (Figure 6) is designed for students and their parents. It is created with the React Native and exported for the two major mobile platforms currently in place - Android and iOS.

Figure 6. Mobile Client Side
Source: Our work

It stores information about the games provided in the **Game Library**, settings for the user, and a list of available games.

The architecture allows games to be added within the list without further update of the application. Figure 7. represents a game for beginners which is a simple card matching game.

Figure 7. Card Matching game delivered from Game Library
Source: Our work

CONCLUSION

The educational opportunities provided by game-based learning methods are rich and correspond to the child's nature of learning. The theoretical background of the methodology implemented in our project is Constructivism and a child centred approach to learning considering individual's interests, cognitive ability, strengths and challenges. The created application aim to support SEN students and consists of games and resources supporting development of skills to process information, problem solving, planning, organizing and expanding knowledge about science objects and phenomena, ecology, human body and health. The detailed description of background, software architecture, domain and design of the software in this article provides an opportunity to discuss our project with academic community and share experience and good practice.

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EDUCATIONAL POTENTIAL OF MASS MEDIA: REALITY AND PROSPECTS FOR E-LEARNING

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Abstract: *The article is devoted to educational, informative and cognitive functions of mass media. The paper discusses a modern scope of the use of various media in teaching activities, as well as the need and motivation of public administration students to use the educational potential of the media. The paper outlines didactic prospects of newspaper materials, radio, TV and the Internet. Analysing and discussing mass media materials in practical classes on socio-humanistic sciences boosts students' cognitive activity and develops general and professional competences.*

Keywords: mass media, press, radio, television, internet, education, university

INTRODUCTION

In conditions of ongoing development within the information society, the development of distance and e-learning, the use of mass media in university teaching is becoming of particular importance when it comes to improving students' motivation for learning and to ensure practical orientation of higher education. Today, the media provide professors and students with unlimited opportunities to design educational process for the benefit of both parties: lecturers use practical examples to explain complex theoretical topics to students, and students – improve their level of professional and general knowledge of the materials of the press, television and the Internet and present their thoughts on this topic at seminars and practical classes in the educational institution. The transformation of the traditional paradigm of higher education is making the media active participants of the educational process, along with teachers and students. With the increase of independent work of students, the individualization of training, the development of Internet technologies and the immersion of most modern youth in social networking environment, teachers no longer determine what and when to transfer to students so that they develop the necessary skills, knowledge and abilities for further work and social life – this role is assumed by the media, and especially television and the Internet. Modern youth cannot imagine living without the Internet and puts it above traditional library work and reading the paper versions of scientific journals when it comes to absorbing knowledge. However, periodicals, radio broadcasts, and TV news also have a significant educational potential, which will be addressed later in this article.

1. PREVIOUS RESEEARCH ON THE ROLE OF MASS MEDIA IN EDUCATION

Unfortunately, in the contemporary scientific discourse these aspects are not widely discussed, since, as a rule, only a few aspects are considered. Mass media are mostly analysed in terms of their impact on the process of socialization; formation of their value consciousness, media culture and mentality; the dynamics of media presence, media consumption and media preferences of young people; the structure of media audience and the peculiarities of transformation in modern conditions, as well as the identification of the forms and methods of mass media influence. In general, the degree of scientific discussion of media use in the educational process is quite fragmented and one-sided, since most scholars are focusing on media education, while its introduction at all levels of the educational system of Ukraine is actively debated.

However, the scientific community rarely discusses the use and analysis of materials and mass media publications at classes on specific disciplines, especially when it comes to traditional media. General facts about functioning of the media in university educational environment were highlighted by O. Shypko (Shypko 2014); media sources for individual learning that can be used in traditional education and conditions of improving the efficiency media-enhanced learning were identified by T. Poiasok (Poiasok 2014). The use of the press at university classes is explored solely as a means of improving the professional competence of students of linguistics, and the possibility of applying them to a wider student audience of all specialties when studying humanitarian disciplines is practically not considered in the latest publications. Only K. Fendrikov analysed university press as an integral part of the educational environment in a pedagogical higher educational institution (Fendrikov 2015). The scientific discussion of educational prospects of radio broadcasts is practically non-existent.

The authors of this article published a few papers devoted to various aspects of optimizing the educational process in higher education institutions by modern

ICT, namely: the use of media objects, thematic sites, electronic educational books in teaching sociological courses, promising directions for improving teacher-student interaction through wider implementation of ICT in the educational process (Shelomovska, Sorokina, Romaniukha, Bohomaz 2017); prospects of the official university website, electronic repositories, information portals, professors' personal pages, websites of leading sociological centres, educational literature and periodicals in teaching sociology and activating cognitive activity in university students (Shelomovska, Sorokina, Romaniukha 2018), etc.

However, all these works do not fully describe extremely diverse educational potential of mass media in the university educational process during social change. A comprehensive analysis of the educational capabilities of the press, radio, television and the Internet, identifying the needs of education and teaching staff in accessing them, defining the prospects for using mass media information in e-enhanced learning have not been so far the subject matter of a separate scientific study, which stipulated the purpose of our study.

2. PRESENTATION OF RESEARCH RESULTS

Today mankind exists in such a social environment, where media turned from the mediator into an environment of human existence; an environment in which the political, economic, socio-cultural, and educational codes of mankind are produced, aesthetized and broadcast. Media has long been an integral part of our lives. Today, we can observe mediation of all spheres of life in the information society, including higher education.

As researchers point out, media exert significant influence on the development of children, allowing polemics about media or screen socialization. Scientists prove that children starting from two years old are active media users at the initiative of their parents. At the age of three, they have developed preferences among media products, and by the age of five pre-schoolers already have considerable experience using gadgets and the Internet. It should be noted that early introduction of children to the media and educating them on media objects in the family forms a new type of relationship with intricate media environment which was called media socialization (Semeniako 2016).

The significant influence of the media on public consciousness is possible due to their ability to quickly and almost completely reach the widest audiences and transform the traditional system of education and training. Besides, the media have various opportunities to influence individuals' lifestyle and behaviour both by solely informing, and with the help of practical examples of lifestyles. There are two aspects here. First, the media significantly helps assimilate a wide range of social norms of people of different ages and shape value orientations in politics, economics, health, law, etc. Secondly, the media is in fact a peculiar system of informal education and education for wide audience. At the same time, users of the media absorb rather diverse, contradictory, unsystematized knowledge, information on various issues of social and political life. Today well-developed socio-political systems are dominated by the idea that those who own the media impose public opinion (Subashkevich 2016).

Today, the young people are the main recipients of considerable portion of media content. This community is best oriented in the modern media world and is actively involved in both the consumption of media content in its various manifestations and self-presentation through the Internet. Student youth, first of all, university students, are virtually completely involved in the media environment due to active consumption of media products and the creation of their own media content. However, unlike the older generation, young people do not break old media behaviour patterns, but form their own model, which comprises various communication tools, sources of information and ways to receive it (Zinchina 2016).

Generally, media popularity among young people is determined by the following factors:

- dominance of visual entertainment, standardization, seriality, sensationalism, system of "emotional fluctuations" that allows to discharge the nervous tension of spectators,
- hypnosis, pleasing the public, intuition,
- availability of therapeutic, compensatory, recreational, aesthetic, moral, social, communicative, informational, cognitive, etc. functions (Semeniako 2016).

In the context of our study, we consider it worthwhile to scrutinize in detail the essence of the informative and cognitive function of mass media that perform a common task. On the one hand, due to mass media it is possible to accumulate and multiply information, preserving previous experience, and the media themselves in this case act as guarantors of the information provision of society. Thus, the essence of the information function is that media consumption, acting as a carrier of social information, in connection with the active development of information and telecommunication technologies, is a special type of information process, a set of information and communication tools. Actually, television has become a media symbol of the XX century, and the Internet – the symbol of the XXI. However, this became possible due to content, namely, methods, forms, methods, channels, technologies for communicating information to the media consumer, media user (Isaienko 2017).

On the other hand, the culture of media consumption turns people into subjects of knowledge and understanding: it offers them knowledge and activates curiosity. The epistemological significance of the culture of media consumption exists in two modes: first, in the accumulation of absorbed information on various issues, and secondly, in stimulation of information needs arising on the basis of the acquired information. The culture of media consumption accumulates a huge array of knowledge, ideas about the world, events, public figures - the essence of the revised TV programs, consumed radio broadcasts, read books and newspaper texts, etc. The culture of media consumption is an area not only already acquired from media sources, but also the one that can be experienced with certain effort of the interested media consumer. For example, thoughts, reviews, and evaluations of certain media products, which spread like a manifestation of civic media criticism, may encourage other media consumers to get acquainted with the recommended media products (Krajnikova 2014).

The modern university and the training of a highly skilled specialist is impossible without taking into account the analysis of the surrounding social reality and the impact of intense, continuous information flow on the student. In this regard, the problem of the universities is to find ways to use this information for educational purposes.

The results of sociological research indicate that education providers feel the need to use the media as educational resources, as the formation of their personality takes place in the context of intensive intellectual development, which promotes training in higher education institutions.

The authors conducted a sociological study "Student Youth Experiencing Ukrainian Reforms" in May 2018 to identify the dynamic changes in consumption of various media products by modern youth. The collection of primary sociological information took place at the leading universities of central Ukraine. Graduates from the first (Bachelor) and second (Master's) levels of higher education of the Dniprovsky State Technical University (DSTU) in Kamianske, O. Gonchar Dniprovsk National University (DNU), Dnipro, Dnipro Regional Institute for Public Administration, National Academy of Public Administration under the President of Ukraine (NAPA), and Kryvy Rih State Pedagogical University (KRSPU), Kryvyi Rih. The common sample amounted to 28.1 thousand people (20 thousand students from DNU, 3.6 thousand from KRSPU, 4,5 thousand from DSTU according to the website www.education.ua). Purposive sample was 379 people, which, with 95% probability and 5% error confirms the reliability of results. We used the method of simple probability selection. The sample is representative by sex and year of study. It included 180 students of DSTU, which comprised 56.4% of the total number of respondents, 65 students of DNU (20.4% of respondents) and 74 students of the KRSPU (23.2% of respondents) aged 17 to 35 attending various presence courses.

The sociological survey was conducted by anonymous questionnaires in oral form. The sample is representative of the gender and year of study. The universities involved represent long-standing educational traditions in the region, and therefore the answers of the interviewed students can be extrapolated to undergraduate graduates of central Ukraine. The empirical basis of the study allows us to draw some conclusions about the specifics of media consumption and media culture of modern undergraduate students.

Thus, according to the results of a sociological survey conducted by the Department of Sociology of the Dniprovsky State Technical University (Kamianske, Ukraine) with the participation of the authors, it turned out that the majority of respondents considered the information of cognitive nature to be the most interesting in the media, as almost 70% of respondents expressed their interest (Figure 1).

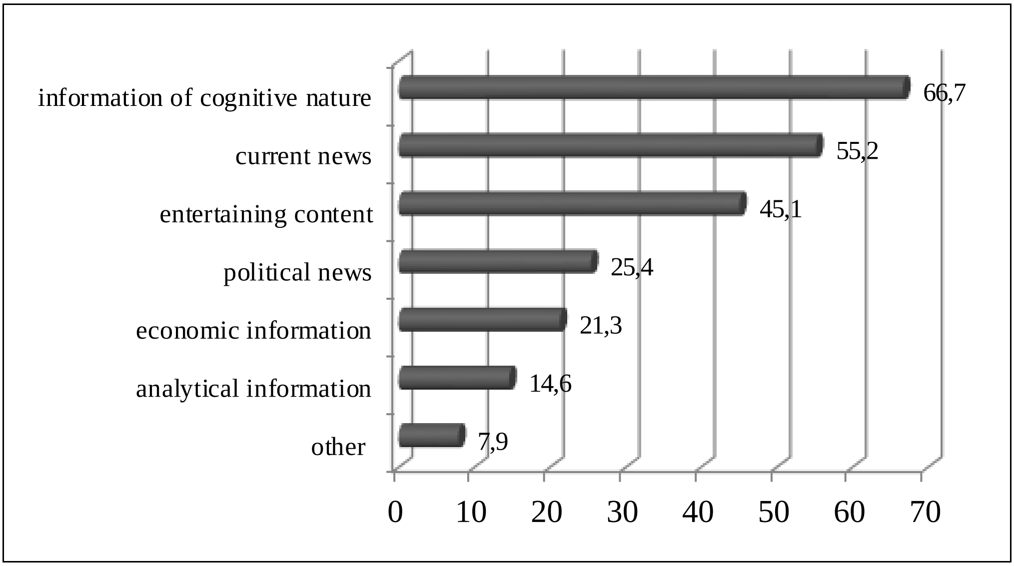

Figure 1. The most interesting information for students in modern media (in %)
Source: own research

At the same time, every second student is interested in current news (55,2%), while entertaining content is in third place in popularity – 45,1% of those polled chose it. The smallest number of respondents chose analytical materials, economic information and political information (only every fourth student).

2.1 The use of periodicals in teaching

In view of quite significant students' demand for information of cognitive nature from the media, the desire to receive it and discuss in the process of learning, we consider it appropriate to dwell more on the prospects of the press, radio, television and the Internet in teaching sociology and training of sociologists.

Periodicals are traditionally one of the mainstream media and propaganda. Newspaper materials contain facts, their assessment, characteristics of processes and development trends. The newspaper expresses an opinion on the most important political and social problems, seeks to provide the reader with a complete information worldview based on published materials The use of newspaper texts improves students' motivation, since they are based on novel and relevant material, which is undoubtedly attractive to students. Thus, its use in the educational process will build general and socially-oriented competence in students, which is especially necessary for the integration of the individual into global culture, mutual understanding of people and cooperation. At the same time, the newspaper material is similarly attractive to the teacher, as with increased motivation one can improve his or her own skills analysing various social phenomena, expand background knowledge and increase professional thesaurus.

One can outline the main methods of working with media materials. Working with the newspaper can be carried out frontally (with teacher or coach's guidance), when all work together work on an article, and individually, when each student receives a separate task, aimed at forming the skill of critical thinking, analysis of a specific socio-political situation and the ability to apply sociological concepts, frameworks and theories for the interpretation of social phenomena and processes in practical situations. The essence of such a task can be manifested in the selection of news materials for a certain topic; preparation of small messages based on collected materials, plans, tables, diagrams, reading and commenting on newspaper materials; group analysis and preparing answers to the professor's questions, etc.

Currently, the popular media format in Ukraine now is television broadcasts devoted to the discussion of interesting news materials, and therefore, in our opinion, this form of entertainment may be an interesting part of a class. On the one hand, it is impossible without thorough individual preparation of students, because they have to cover a large array of information and present a topic that will not only be interesting to other students, but also allow them to cover a certain study topic. On the other hand, this format allows engagement of practically an entire student group in discussion, because in the game form, students will no longer feel the pressure of the university walls and they will just enjoy arguing with their group mates. Many students evaluate game-like discussion of newspaper materials as more enriching and engaging, since different types of didactic materials are used.

However, newspaper materials as educational information must meet certain requirements. It is important they:

- take into account the needs and interests of students (contain elements of novelty, newsworthiness);
- take into account the future occupation and professional interests;
- correspond to the topic studied, be aimed at solving a specific educational task;
- take into account socio-cultural realities (Isaieva, Sabans'ka 2015).

Thus, the achievement of pedagogical goals of learning largely depends on the teacher's ability to select sources, materials, determine their propriety in classes, and organize the discussion of a particular article through the use of the most effective methodology. When selecting texts, the following should be taken into account: they must expand, specify, update knowledge, but not overload students; to serve as a basis for comprehending present-day phenomena; to be logically linked to the course material, to be accessible in terms of content and volume; to promote the development of learning path and students' cognitive skills.

2.2 The use of radio in classes

The radio is not perceived as a source of news or cognitive information because most often it is used by young people solely as a convenient means of listening to music as a background for other lessons. However, today the radio is the most active source of information about local and global events, since it is possible to broadcast it from anywhere on the planet simultaneously with the development of the story itself. Due to this, you can hear live commentary from the public, public figures, reputable people in all areas of knowledge and, of course, the participants themselves about what is happening. In light of this, news releases that are broadcast on an hourly basis can be the subject of an on-line discussion in student groups. The advantage in this case is the fact that students learn without prior study to analyse events and develop the skills of critical thinking and forecasting further development of events. In addition, they do not suffer from a visual image imposed by television channels – students can construct their own picture of events with their imagination. Radio frees up the imagination and in some way compensates for emotional and mental stagnation, automatic behavioural patterns that are formed by life and educational experience.

However, the radio as an audio kind of media can also be used in individual students' work, because it does not require being completely abstracted from everyday activities. Listening to radio along the way to university can be a productive background to prepare for classes. Teachers should take advantage of this fact and give individual homework to students to listen to a particular radio programme and make its detailed analysis. On the one hand, it will increase students' interest in the course material, as it will be unexpected and innovative, and will become an effective change compared to theoretical abstract preparation, which is considered boring by the students. It will require creativity and originality of approaches that students will definitely want to demonstrate. On the other hand, this will, of course, also require thorough training of the teachers themselves, since students' creativity cannot be developed without their professors' growth.

Hence, the use of radio in education contributes to the effective formation of socio-cultural and multicultural competence of students. When using radio and listening to foreign radio programmes students receive more extensive knowledge of the culture of the country, the lifestyle of the people, about the events that are happening right now. Radio should be used at classes in socio-humanitarian disciplines because they can enliven classes. However, in order to apply radio efficiently one must take into account possible shortcomings of this technical means. For example, the broadcasting time may not coincide with the duration of the class, the programme may not fully correspond to the topic of the class. At the same time, sociological data allow us to say that radio makes people absolutely happy – after listening to the radio, people feel better and more harmonious (Trening). This is another advantage of radio materials used in class, because students will not feel information overload, quite on the contrary - they will talk about good emotional state.

2.3 Television as a teaching tool

From radio and newspapers we switch to **television**, which today is a really popular medium among the entire population of the world. Its ability to present events visually clearly has considerable potential to be used in higher education. The practice of using materials for university studies is based on one of the oldest and most basic methodological principles – the principle of visibility, and its expediency is explained by:

1) the availability of video material that can be recorded from various sources or viewed on-line immediately with the audience;

2) immersion of students into the world, filled with television products, familiar to them from childhood;

3) the possibility of engaging both students and teachers in more intense creative activity.

Classes with TV materials perform educational and upbringing functions, enhanced by high efficiency of visual image. The information presented in visual form is the most accessible for perception, it is assimilated more easily and faster than text and audio. In addition, the use of video at classes helps meet students' inquiries, desires and interests. However, when choosing a TV material to be discussed at an educational session, it is necessary to assess it in terms of content – its relevance for the topic of class, newsworthiness, originality, engaging presentation, compliance with social reality. But at the same time, the TV material must be of such a kind that for its full understanding and efficient discussion students require deeper knowledge of the foundations of social life than those widely accepted. Thus, the motivation of students for a more thorough study of the course increases, and the desire to get positive feedback from the specific material creates additional bonuses for active work in the class. However, students are more interested in the subject when they see the theory under study applied in practice or the paradigm in real life situations of society. This is more motivating than any other factor. A properly prepared TV material can encourage students to discuss, for example, in a role-play or discussion.

Collaborative viewing of the TV material creates an atmosphere of cognitive activity, in which even a non-observant student becomes totally involved in the story. The TV screen permits to widen the students' motivation – the TV-story on the screen induces active reflection as to how one can implement the previously acquired knowledge, it strengthens personal cognitive interest and stimulates its further development within the proposed topic. In this regard, television allows the teacher to intensify the learning process by combining the form, organization, pace of training and audio-visual impact on students with real opportunities for students to perceive and re-classify the study material; make the process of assimilating the material in foreign language livelier, more interesting, problematic, compelling and emotional with the help of a television screen; to control the perception and assimilation of TV-information, to make appropriate adjustments in the teaching process with the help of television (Kravchenko).

When using the visual method (demonstration of TV-materials), the following requirement should be met:

- the video material used must correspond to the students' level of knowledge;
- visibility should be used in moderation, material should be displayed in portions and only at the appropriate time of the lesson;
- observation should be organized in such a way that all students can see the video demonstration well;
- it is necessary to clearly outline the essence of the story;
- one should think ahead of the explanations given during the demonstration of the video;
- the material demonstrated must be precisely aligned with the study material, consistent with the subject being studied (Soljeva 2015).

At the stage of active viewing of the TV material it is important that students realize that they need to be active while browsing rather than simply enjoying and relaxing. Teachers should prepare a number of stimulating (challenging) tasks that will introduce students to several subjects of the video, such as the place of action, situation, background, etc. If students are informed before viewing what they are required to do during a review, it will help them to focus on the proper plots of the TV programme. Focusing on details is required to perform the tasks properly.

Typically, the effectiveness of a video tutorial depends on the students' attitude to video demonstration. For this purpose, special methods of work with video material are offered, namely:

- watching a video with the sound off: students and teachers discuss what they see, what kind of thoughts they are struggling with, and suggest what actors actually say;
- watching in Video off / Sound off mode: here the order of actions is opposite
  to the previous one. While students are listening to the video, they try to guess where the actors are, what they look like, what's going on, etc. After representations, they watch a movie with sound and decide whose script
  was closest to the content;
- watching a sheet of paper – the screen is covered with a white paper sheet and students watch the video through it. They can see only fuzzy outline and then they try to predict what's going on in the video about that. Then they watch the video clip again without the sheet and compare the two versions.
- "freezing" the image: the teacher pauses the video and asks the students to assume what will happen next;
- dividing the group into two subgroups: the first subgroup faces the screen, the second subgroup – with their backs to it. The first subgroup describes to the second subgroup what happens in the video.

The core of the work is exercises of commenting, discussing, interpreting the issues raised in the video. Among these exercises of particular interest are: discussion, round tables, role plays, dramatization, putting their own problem issues related to the video-story (for organizing the discussion), expressing their thoughts on the problem, and others. But in order to achieve the "usefulness" of the review, the teacher must carefully prepare for viewing each piece of video material (Pichuhova 2015).

At the same time, when planning a training session with the use of television, the teacher should remember the challenges of such educational technology, which, however, can be used to the teacher's advantage, provided the teacher works proficiently. First and foremost, students may feel incapable of understanding the tv material. But it is exactly such a misunderstanding that will be useful for the teacher when setting up communication in the group and working out their own and student's ability to explain complex things in simple terms that are clear to all. However, in all circumstances, the proposed tasks should call and support the students' interest in discussing the material. The risk that some of the students have already seen this TV material, on the one hand, will create a healthy competition in the group and will motivate all students for a thorough preparation for the class. On the other hand, those students who have already seen this TV material and those who have not can create teams and discuss the proposed events, based on a certain level of awareness. Also, those students who have already reviewed the material will work out public speaking skills explaining the context of the video and their own view to the student community. In order to avoid accusations of useless waste of classroom time and distraction of students from theoretical training, the instructor has to make a shift from a person who gives knowledge in the finished form to a consultant, who directs the students' efforts to develop their personality in order to achieve efficient educational and professional results. The instructor faces the need to solve the tasks of students' professional and personal development in their new quality of a facilitator, who will not be "above" the student, but "next" to them. It results in modifying the kinds of class activities – from frontal types, where the students are expected to give feedback directly to the teacher towards other collaborative activities where teacher assists students and they work together to perform a task, not necessarily coming from the teacher.

2.4 Using video-materials in class

There is a set of reasons that determine the effectiveness and feasibility of using **films** as a teaching tool – from the availability of video materials that can be recorded from different sources to stimulating the emotional and intellectual activity of students and forming their personal attitude to certain life problems, which is especially important within the course of sociology. Movies and videos contain examples of social life and interaction in a variety of situations and circumstances. Video materials allow you to analyse social statuses and social roles, to highlight examples of social mobility and stratification, to determine the specificity of various communities, and so on. The most successful work with films takes place during seminars as consolidation of theoretical knowledge, as well as in the context of independent work as a recapitulation of the lecture material. The use of films contributes to the development of analysis skills, the formation of students' reflection, the ability to argue their point of view. Of course, in order for the film to become a means of learning for the students, it is necessary not only to organize a productive discussion of what has been seen and to intensify the cognitive activity of students on problematic issues and special tasks, but also to correctly select the content of the film, as well as the place and time of its use (Rassudova 2014).

Video content in the classroom and in independent students' work potentially develops in them a complex vision of surrounding reality and the ability to assess not only theoretical material but empowers them to deal with practical challenges. In this context, we can note the papers by Rassudova L., Korytnikova N., Maksimova L., considering video materials a teaching instrument. Thus, Rassudova discusses didactic possibilities of videos, arguing that they help develop analytical skills, form students' personal opinions, and the ability to argue one's point of view (Rassudova 2014). Korytnikova demonstrates possible directions for the use of documentary and feature films in teaching the course Basics of Sociology for students of non-sociological specialties by implementing three directions of visualization in the teaching process: as a way to accompany lectures and discuss topical notions during seminars. The author argues that films show the most successful outcome during the seminars as they permit to consolidate the theoretical knowledge absorbed by the students, as well as a valuable resource for independent work (Korytnikova 2012). In her study of using video analysis in sociology Maksimova argues that classes in sociology are significantly enriched by video analysis in terms of natural observation of social interaction. Video analytics looks at naturally occurring interactions in everyday situations. In order for this activity to be successful videos are selected from those where the interaction is not staged; frames are not selected in accordance with their artistic value, persuasive power or political significance. Thus, video analysis is a powerful tool for studying social interaction (Maksimova 2016).

2.5 Using Internet in class

In the conditions of e-learning, the largest educational potential at the present stage of the development of society is **the Internet**, which combines the advantages of all the above-mentioned mass media. In a study realized by the European Commission on new ways of obtaining education and training in Europe in 2020-2030, the experts identified the following promising areas and trends:

- open learning through the Internet will become a traditional form of education;
- mobile Internet devices will become the main tool for learning;
- paper books will be replaced by electronic multimedia content;
- multiplayer virtual worlds will make unnecessary presence classes in schools and universities;
- open educational resources will be widely used by all subjects of the educational process;
- the community will not rely on experts as to the quality of knowledge and training programs, but will move towards high-quality knowledge, verified through Internet resources;
- systems and services will be developed to provide mutual group learning among interested schoolchildren and students;
- blogs and other multimedia materials posted on the Internet will be recognized as "legitimate" publications for scientists;
- virtual mobility will break the barriers between national education systems;
- personal learning environments will replace the existing virtual learning environment, etc (Education in Europe).

The forecasted educational trends presuppose intense use of cognitive and educational capabilities of the Internet, testify to the high level of development of the information society and the development of citizen mentality, relevant to the present conditions. Electronic educational resources combine several important didactic functions, the complex combination of which allows using ICT in the learning process. They permit to preserve and reproduce the content of learning, to visualize and demonstrate the educational material in action, to help students form a comprehensive idea about the social reality in the integrated sense. Already, electronic educational resources are an integral part of the educational process, have educational and methodical purpose, are used to provide educational activities and are considered one of the main elements of the informational and educational environment.

The versatility and extraordinary potential of using web technologies in educational and scientific activities permits to highlight the main functions of the appropriate use of websites: information-presentation, advisory, informational, methodological, educational, supporting, etc. (Konevshchins'ka 2015).

Classes using Internet resources open up new opportunities for students, especially for self-education. Searching information on the Internet for a properly set task in the classroom is now a prerequisite for the formation of students' information competence. The use of information and communication technologies makes it possible:

- to provide positive motivation for learning;
- to provide a differentiated approach in education;
- increase the amount of work performed in the classroom;
- efficiently organize and improve the efficiency of the classroom;
- improve knowledge assessment;
- develop skills of real research activity;
- provide access to various reference systems, electronic libraries, and other information resources (Alyoshina 2016).

For effective use of Internet resources in practical classes or for the organization of independent work, it is necessary:

- to have a well-designed Web-based lesson plan, with a definition of the purpose, place and time of using Internet resources;
- to make an algorithm of action with clear instructions for each type of work;
- to have a clear idea of which skills and competences will evolve.

- provide assessment criteria against which the trainees can be judged on the progress and correctness of the task (e.g. key tests, forms for assessing in groups, in pairs, thinking evaluation of oral answer when the task was to make judgments or justify the idea);
- use websites that are selected by the criteria of effectiveness and relevance to the subject matter of the training material.

The use of Internet resources will be particularly useful when improving the distance and e-learning system, as it fills the united information and education environment, gives users access to domestic and foreign sources of information, opens up new perspectives for individualization of education, allows one to significantly improve the forms of open education and the use of online potential of distance learning. In fact, the very use of educational Internet resources in universities allows one to comprehensively develop cognitive, moral, ethical, creative, communicative and aesthetic abilities of students. The use of these opportunities in educational activities transforms the usual lessons into an extremely exciting and creative learning process. Modern educational Internet resources can provide knowledge transfer and access to different cognitive information on an equal footing, or even more efficiently than traditional learning tools. That is why electronic tutorials are an urgent need of the present. In addition, thematic Internet sites allow not only to search for information, but also to solve many educational tasks. Their use can increase the motivation of students, since by using the Internet at classes students plunge into the familiar information environment. Online electronic educational libraries provide a wealth of materials to prepare for seminars, discussions, independent work of students. Through the sites of periodicals, students have access to the latest publications on pressing topical topics in sociological journals.

CONCLUSION

In the context of e-learning, the transformation of the educational process will highlight the need for the intensive integration of the media into modern university teaching, as this will ensure more efficient development of students’ general and professional competence and will allow future professionals to perform their duties in a qualified way. The very use of media in the educational process involves a variety of tasks, updating the textbook information, teaching to evaluate the modern media styles. It is the mass media that enables students to study humanitarian disciplines in the modern social context, to understand the usefulness of theoretical knowledge in relevant real life situations. They can be applied practically at all stages of training, when working with students of various specialties, because they provide gradual formation of skills and significantly expand the possibilities of training. Information from various media sources, in contrast to the educational material, has a number of attractive features for young people: it is emotionally rich, relevant, and accessible for understanding, does not require learning and is not subject to unambiguous assessment.

The use of mass media is particularly effective in social and humanitarian courses, where discussion of media materials and messages helps not only to increase students' interest and motivation to study, but also to keep abreast of current events in various areas of public life, to accumulate social and political material, get acquainted with innovations, shape your own worldview and identity. The use of media in the educational process contributes to the socialization of students, teaches them independence, and develops individuality as well as the desire to be enriched. Mass media provide a variety of forms of training from reading newspapers, listening to radio and watching videos to working with Internet sources, as there is a simultaneous impact of text, graphics, sound, photo and video information. On the one hand, their integrated application may make classes and the whole educational process more engaging, more dynamic, more informative, and on the other, they lead to better learning outcomes, better quality education and improve the efficiency of learning.

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THE USE OF E-LEARNING IN EDUCATION FOR PEOPLE WITH MILD INTELLECTUAL DISABILITY IN THE CONTEXT OF THEIR MENTAL WELL-BEING

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Abstract: *The use of modern information and communication technologies by people with mild intellectual disability, which enables the application of e-learning methodology, i.e., distant learning based on information and telecommunication technologies, is definitely part of the current trend of media education also in this social group. It is worth remembering that in addition to profits which result from engaging people with mild intellectual disability, such as autonomously making decisions and choices or establishing social relationships, the development of modern information technologies is often related to reduced interpersonal contacts face to face and may contribute to the crisis of fundamental values, which may potentially be dangerous to the person's mental well-being.*

The paper discusses the issue of using e-learning education as a modern information and communication technology in the process of educating people with mild intellectual disability. It also analyzes the relationship between using those civilization achievements and the mental well-being of people with mild intellectual disability.

Keywords: intellectual disability, e-learning, Internet, mental well-being

INTRODUCTION

In the contemporary world dominated by quickly developing modern information and communication technologies, where distance learning is used more and more frequently, both in universal and higher levels of education, we should not ignore the issue of using e-learning understood as the process of transmitting selected pieces of information via various electronic carriers (Penkowska 2010), also in the education for intellectually disabled people. This issue is especially important because the group of intellectually disabled people is usually absent from

Polish and international literature concerning the problem of the use of modern information and communication technologies by people with special educational needs, which makes them "excluded among the excluded" (Plichta 2012 p. 74). Many authors (i.a., McCliments, Gordon 2008, Seale 2007, Plichta 2012) point out the shortage of scientific works concerning online behaviours and new media use of intellectually disabled people. This problem is also important because the environment of new media, including the Internet, is extremely significant nowadays, both for socialization (allowing intellectually able and disabled alike to communicate and establish interpersonal relationships) and for education (allowing them to acquire knowledge and raise their professional qualifications).

In the time of this dynamic development of modern information technologies, often connected with reduced direct interpersonal contacts, we can see an increasing crisis of fundamental values, often resulting in emotional problems and lower well-being. Therefore, it seems vital to discuss the problem of relationship between mental well-being and the use of current ICT solutions, including e-learning, that is, education via modern information technologies (Łysek 2005), not only with reference to healthy people but also to those with disabilities, especially intellectual disabilities.

The leading goal of the presented article is to pay attention to a new and significant problem of the modern technology information, especially the e-learning method which might determine the mental level of well-being people with the intellectual disabilities. The link between the new technology information and the mental stage of well-being people with the intellectual disabilities leads to a predicament which is a research gap. However, the presented article has got the theoretical nature where the implemented methodology in use contains synthesis of literature of the subject and its critical analysis. This particular research method gives an opportunity of the subsequent usage of scientific exploration and the induction processes. Moreover, it allows to carry out advanced empirical research whose results may become a significant contribution to science.

1. MODERN INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE LIVES OF INTELLECTUALLY DISABLED PEOPLE

Discussing the use of modern information and communication technologies (ICT) by disabled people, including those with intellectual disabilities, we need to point out that in our quickly changing world, these technologies have become an indispensable element of daily life of nearly all humans, regardless of their level of ability (or disability). As Plichta emphasizes, a very important area of life opportunities and full participation in the world currently is the access and ability to use modern media – simply speaking, the Internet and its many functions (Plichta 2013, p. 122). The importance of ICT competence, understood as "the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet" (Recommendation of the European Parliament 2006), is stressed by the fact that it was regarded by the European Parliament and the Council as one of the eight key competences that play a significant role in lifelong learning. Knowing how to use modern technologies has become necessary in many aspects of functioning of a contemporary human, from looking for and doing a job, through effectively searching for information, establishing and maintaining social contacts, developing one's interests, spending leisure time in an interesting way, up to education and raising professional qualifications (Chudnicki, Mielczarek 2018).

Hence, the issue of using modern information and communication technologies (including the Internet) by people with intellectual disabilities should definitely be discussed, especially that the use of modern technologies by disabled people, let alone people with intellectual disabilities, is rarely the subject of scientific works (Chudnicki, Mielczarek 2018 p. 250).

Discussing the problem of using modern information technologies, we need to point out that one of the groups with particularly difficult access to these technologies is intellectually disabled people, who are at a huge risk of exclusion, also digital exclusion. The cause of this is not only that they do not have the needed equipment or Internet connection. There are more factors, such as individual needs, access to media education and its quality, enabling the person to use the new media in a way that is adjusted to their needs and capabilities. It seems, as Plichta points out, that in the area of education, we too often concentrate on ensuring physical access to ICT only, not on proper training for teachers, modifying curricula or in-depth reflection on how to use those technologies, both in teaching and in personal development (Plichta 2012 p. 70).

Using new media seems to have a positive effect on the quality of life and social inclusion, whereas limited access to modern information and communication technologies increases disproportions in many spheres, i.a., in educational, social, economic and political one (Chudnicki, Mielczarek 2018). In addition, modern information and communication technologies seem to play an important role in the process of social integration of marginalized persons (Plichta 2012), and this group definitely covers people with intellectual disabilities.

When analyzing the issue of intellectually disabled people using modern information and communication technologies, we need to stress that the problem can only be discussed with reference to people with mild intellectual disability, because in the case of the other groups of intellectually disabled people, especially those with severe or profound intellectual disability, the capability of autonomously using the computer and the Internet is very limited, and in some cases, even impossible.

Since this work presents the analysis of the application of e-learning in education for people with mild intellectual disability, the very term of intellectual disability (for many years referred to as mental retardation) needs to be explained. The American Association on Intellectual and Developmental Disabilities (AAIDD) has proposed a new, more positive definition of intellectual disability: "Intellectual disability is a disability characterized by significant limitations in both intellectual functioning and in adaptive behavior, which covers many everyday social and practical skills. This disability originates before the age of 18" (Luckasson et al, 2002, p. 1). Unlike the previous model stressing deficits and limitations of the person, the current approach to intellectual disability defines intellectual disability with reference to support necessary for the person with intellectual disability to function autonomously in the society as much as possible (Polloway 1997). The definition proposed by the American Association on Intellectual and Developmental Disabilities is based on IQ scores below the threshold value of about 70 as one of the criteria decisive for intellectual disability. In mild intellectual disability, IQ is between 50 and 69 points, and this kind of disability results in learning difficulties with retained ability to work, maintain proper social interactions, and contribute to the life of the community (Smith 2009).

It is worth pointing out that new information and communication technologies may play a key role in all the three basic areas of intellectual disability, such as cognitive difficulties (e.g., problems with memorizing, informal learning and generalization of learning), adaptive difficulties (e.g., the ability to function autonomously), and the need of support in autonomous, independent living. As argued by Plichta, in our times, adaptive abilities do not only refer to the offline environment, but they should also be analyzed from the perspective of availability and use of modern media. Therefore, the environment of modern information technologies, particularly the Internet, which makes distance learning possible, is the place where the potentials of disabled (including intellectually disabled) people can be revealed, and where opportunities arise for fuller participation of this group in social life (Plichta 2012).

The available studies and analyses, though few, clearly show that people with intellectual disabilities are active Internet users, who autonomously engage in various activities to satisfy their needs in their leisure time (Plichta 2012). The report from the "Niepełnosprawny w sieci" *["The Disabled on the Internet"]* study involving 2,000 people with disabilities, including 500 persons with intellectual disability, confirms the optimistic image of the Internet as a tool that significantly helps improve the situation of people with disabilities and allows them to overcome various problems they face daily. The report shows that among people with intellectual disabilities, the most active Internet users are males with mild intellectual disability aged 25-40 (Raport z badania „Niepełnosprawny w sieci" 2012), i.e., the age group probably most interested in acquiring knowledge and raising qualifications not only in the traditional way but also via e-learning. It must be emphasized that people with intellectual disabilities use the Internet in a similar way healthy people do, which suggests that they are probably able to use e-learning courses like the healthy ones. People with intellectual disabilities also treat the Internet as a source of recreation, they look for jobs, establish contacts with other disabled ones and publish their works online, though they use it to search for information somewhat less frequently than healthy people do.

To sum up, the scope of using modern information and communication technologies by people with mild intellectual disability is surprisingly broad, and their media competence is highly developed. Besides, modern information and communication technologies also allow disabled users to move on from consuming the content (like when watching TV) to more active behaviours (Plichta 2012 p. 80). The examples of such active behaviours may be making independent decisions and choices relevant to the person's preferences, or publishing their own works (photos, comments, works of art) online. Such activities also seem to be significant in the case of people with mild intellectual disability, contributing to the improvement of their mental well-being, although obviously we should remember the threats associated with using the Internet, especially for individuals with intellectual disabilities, who are susceptible to the influences of the environment. Thus, we should be particularly careful to educate intellectually disabled people about the safe use of modern information and communication technologies.

2. E-LEARNING IN EDUCATION FOR PEOPLE WITH MILD INTELLECTUAL DISABILITY

Apart from being used in leisure time, in establishing and maintaining social contacts, for pleasure and recreation, the computer and the Internet are undoubtedly good educational tools that can be used in teaching students with mild intellectual disability, especially that, as already mentioned, these people find it relatively easy to use modern information and communication technologies. A computer with an Internet connection can be used in distance learning, enabling not only healthy people but also those with mild intellectual disability to do various courses and raise their qualifications. The use of e-learning in the group of people with mild intellectual disability seems to be particularly justified, as research results confirm their positive engagement in online activity. The report from"The Disabled on the Internet" study (2006) showed that 29% participants with mild intellectual disability publish their works (e.g., graphics or music they compose) on the Internet, and even 81% participants with mild intellectual disability search for information they are interested in online. The data shows that modern information and communication technologies are extremely attractive for people with mild intellectual disability. It seems the attractiveness of the Internet and modern information technologies for intellectually disabled people is mostly associated with elements such as immediate gratification, the sense of power, the sense of agency and control, i.e., experiences that are often absent from the daily lives of intellectually disabled people (Plichta 2012). This fact may be especially important with reference to e-learning, because when doing an e-learning course, the student has the opportunity to receive immediate feedback concerning the effects of their work, and thus, immediate gratification. Carrying out the tasks as part of e-learning courses may also give the sense of power, agency and control, whose deficit is usually experienced by people with mild intellectual disability in many areas of functioning.

The use of e-learning in education of people with mild intellectual disability seems to be justified also because they usually have limited communication and social competences, which makes their direct social contacts difficult, so they prefer indirect communication, e.g., via the Internet or in the form of short text messages. The Internet has properties that are vital for disabled people, the most important of which are properties that make it a useful tool facilitating communication and giving the disabled a chance to be treated like healthy people (Thoreau 2006), which most probably enhances their self-esteem and faith in their competences, contributing to better effects in the educational process. Therefore, it seems that teaching with the use of computers and the Internet, i.e., e-learning, may be especially important for intellectually disabled people, contributing to the development of positive feedback between faith in their own competences and educational successes (faith in one's capabilities facilitates coping with various tasks, and effective coping with tasks strengthens self-esteem). Actually, for some people, the use of the Internet can be a tool to strengthen their self-confidence and play a therapeutic role (Campbell, Cumming, Hughes 2006).

It is also worth pointing out that limiting the importance of linguistic competence in solving various tasks involving the use of modern information and communication technologies may be a factor that facilitates the experiencing of success for people with mild intellectual disability. Furthermore, virtual environment also contributes to the development of cognitive flexibility (Plichta 2013). It must be emphasized that knowing how to use the Internet, referred to as "digital agility" (Seale 2009), is very important for the way disabled people are perceived by the society. Those individuals with intellectual disabilities who know how to use modern technologies are less often perceived as helpless victims of social exclusion (Plichta 2013).

The study on long-term effects of a programme to improve the skills of using modern information and communication technologies by intellectually disabled people proved that the programme has far-reaching, positive consequences, and its participants have gained more self-confidence in helping their family members use computer technologies at home. In this context, the role of teachers in promoting the use of computers by intellectually disabled children (Plichta 2013), particularly promoting educational benefits resulting from e-learning, is of key importance.

Discussing the subject of distance learning using ICT, we must mention how these technologies influence the human brain. Research results confirm significant consequences for the neurorehabilitation and stimulation of cognitive processes in Internet users (Dylak, Ubermanowicz, Chmiel 2009). As argued by Plichta (2013), it seems very interesting to use the phenomenon of plasticity of the brain and neurogenesis, especially in performing tasks with a low level of repeatability. Specific activity activates the selected area of the brain and causes permanent alterations in it. Intensively searching for information on the Internet leads to noticeable changes in brain activity, which do not occur in people who do not use modern information technologies or use them to a little extent. We find out that "Daily exposure to high technology … stimulates brain cells alteration and neurotransmitter release, gradually strengthening new neural pathways in our brains while weakening old ones" (Small, Vorgan, cited in Dylak 2012, p. 125). Dylak (2012) emphasizes an important property of modern information and communication technologies: a feedback loop, which is especially important for people with limited opportunities of experiencing rewards in the form of positive consequences of their activity, and thus, little chance of receiving immediate gratification. Combined with intellectually disabled students' difficulties in obtaining quick effects of their activities, modern information and communication technologies which allow distance learning to offer much greater opportunities to experience success (Plichta 2013). For this reason, the use of e-learning in education for people with mild intellectual disability seems to be particularly important for the development and mental well-being in this group of people, though this issue is obviously complex and requires further studies and analyses.

3. THE USE OF E-LEARNING BY INTELLECTUALLY DISABLED PEOPLE AND THEIR MENTAL WELL-BEING

The analysis of relationships between mental well-being (whose key component is positive experiences, e.g. experiencing happiness) and the use of contemporary IT solutions, such as e-learning, i.e., education via modern information technologies (Łysek 2005), is an important problem, because according to research results, the benefits of positive emotions, satisfaction with life and optimism are totally measurable and objective, and happiness is like a lottery ticket: it gives you a chance for success (Czapiński 2004 p. 237). Research carried out so far clearly shows that happy people have more successes and prosper better than unhappy ones (Czapiński 2004; Porczyńska-Ciszewska 2013), which is definitely significant for the functioning of both healthy people and those with disabilities, including intellectual disabilities. Many studies show that people who frequently experience happiness enjoy more satisfying interpersonal relations, better health and longer lives, as well as higher income and professional successes, for the very reason that they are happy (Danner, Snowden, Friesen 2001;

Czapiński 2004; Pressman, Cohen 2005; Marks and Fleming 1999; Porczyńska-Ciszewska 2013).

Although in many scientific works modern information and communication technologies, especially the Internet, are criticized and blamed with various problems their users have, such as Internet addiction, weaker family and social relationships or problems with direct interpersonal communication, we need to remember that the Internet is often used to spend free time, and as we know, satisfaction with one's free time is one of the components of the general well-being index (Campbell, Converse, Rodgers 1976). Online activity also offers the opportunity to make independent choices, develop one's interests or establish social contacts that can be continued offline. Having interests and being able to carry them out, just like establishing and maintaining contacts with other people, definitely has a significant impact on human's mental well-being. Research outcomes show that benefits resulting from carrying out one's interests in the free time may be i.a., the improvement of perceived quality of life, acquiring adaptive skills (Badia, Orgaz, Verdugo, Ullan, Martinez 2011), reduction of emotional tension and stress, better mental health and better cognitive functioning, or an increase in self-confidence and self-esteem (Patterson, Pegg 2009). As mentioned before, one of the main sources of satisfaction with one's free time is social interactions and development of interpersonal relationships (Argyle 2004), which is also facilitated by modern information and communication technologies, especially in the case of intellectually disabled people. Leisure time is undoubtedly an important element of general life satisfaction (Argyle 2004), both for disabled and healthy people, and spending it in a constructive way is positively correlated with mental well-being. In addition, actively spending leisure time, correlated with well-being, proves to be a predictor of future happiness. It must also be stressed that in the case of people with intellectual disabilities, active ways of spending leisure time are not always the result of their free choice but may be determined by the decisions of their healthy caregivers, which may have a negative influence on their mental well-being. It is so because there is a negative correlation between engaging in activities the person cannot control and their mental well-being (Holder, Sehn, Coleman 2009). Furthermore, it has been confirmed empirically that engaging intellectually disabled people in so-called serious ways of spending leisure time, which may mean active and constructive use of the Internet in the form of e-learning, helps fight against the stigma and negative attitudes toward intellectually disabled persons, ensuring their visibility and respect of others (Patterson, Pegg 2009).

Due to very promising results obtained in the scale of positive engagement in online activity by people with mild intellectual disability (Plichta 2012), it is worth pointing to the concept of happiness proposed by M. Csikszentmihalyi (1990) referred to as flow experience, also called the "engagement concept". According to M. Csikszentmihalyi, flow experience means the state of maximum engagement, in which the person's skills suit the level of the task the person is carrying out. Experiencing happiness, which M. Csikszentmihalyi calls flow experience, is the state when people feel deep satisfaction, and the mental state called flow means concentration to the point of complete immersion in the present activity. Usually it is connected with the feeling of strength, freedom, lightness and effortlessness. Someone who is experiencing happiness has the impression of controlling the situation, has no doubts or complexes, and uses their abilities to the full. The person loses the sense of time and emotional problems and feels wonderful, complete joy (Csikszentmihalyi 1997). We can say, then, that it is the state of maximum engagement in the present activity.

Research results prove that flow experience involving concentration, control and pleasure may lead to better learning effects (Yi Maggie Guo, Young K. Ro 2008). The most important conditions necessary to experience happiness in the meaning of flow, such as balance between the challenge and one's skills, feedback and transparency of the goal, are actually the elements that link optimal experiences with learning, also learning with the use of modern ICT methods.

It seems there is an analogy between acquiring knowledge and raising one's competences through e-learning courses and flow experience. The scholars who study the phenomenon of flow experience have observed that the feeling of flow occurs when the person faces clearly formulated goals which require specific behaviours of them. Usually, e-learning courses are designed exactly this way, to make the student's goals and tasks clear and precise. Moreover, a characteristic element of acting in flow is the presence of immediate feedback: when performing the task, the person knows immediately how well they are doing. This aspect also occurs in e-learning, since the student usually receives feedback after each task done as part of the course. Source literature also shows that the feeling of flow mostly appears in situations when the person's skills are used to the full, when overcoming difficulties or accepting extremely difficult challenges (Porczyńska-Ciszewska, Kraczla, Wziątek-Staśko 2018). Optimal experiences are usually characterised by a kind of balance between the requirements, challenges and capabilities of the person (Csikszentmihalyi 1997). These conditions also seem to be met in e-learning, which mostly includes activities relevant to the student's abilities, and according to M. Csikszentmihalyi (1988), such activities give us the greatest satisfaction and lead to the state of engagement, i.e., flow experience, contributing to the improvement of mental well-being.

Therefore, it seems that both healthy and intellectually disabled people who use modern distance learning technologies have more opportunities to experience the states of maximum engagement, i.e., flow experience, which according to M. Csikszentmihalyi are tantamount to experiencing happiness, and as already mentioned, mental well-being leads to prosperity (Czapiński 2004), which means that happy people fare better, are more successful, and as a result they have higher self-esteem. Therefore, we may presume that using modern information and communication technologies enabling distance learning may be positively correlated with mental well-being, both in healthy and intellectually disabled people. Thus, it is worth stressing that apart from threats such as computer or Internet addiction, problems with interpersonal communication or alienation, modern technology undoubtedly offers excellent conditions for the transfer and popularization of knowledge with the use of distance learning techniques.

CONCLUSION

The discussion on the use of modern information and communication technologies by people with mild intellectual disability, which enables the application of e-learning methodology, i.e., distant learning based on information and telecommunication technologies, definitely refers to an important and hot problem in times dominated by the Internet and the new media. E-learning programs used in education of both healthy and disabled people are oriented at quicker and more effective education of the students who use them and the improvement of their skills in many areas of functioning. However, in the process of designing and applying e-learning education for intellectually disabled people, the qualities of these people connected with the way they use the media should be taken into consideration. These properties are i.a.: susceptibility to media manipulation, especially regarding consumption, adopting negative patterns of thinking as a result of reduced criticism, and inability to critically analyze content that is unclear, ambiguous, not transparent, multivalent or provocative (Krause 2004). Taking these properties into consideration in the process of designing and using e-learning education can definitely contribute to the development of new dynamics of opportunities for people with mild intellectual disability.

When making use of modern information and communication technologies in education for intellectually disabled people, we must not forget that technological innovations, both in communication and in the process of development, also generate a new source of potentially new threats, such as Internet addiction, social alienation, or the sense of isolation. While remembering these threats, we should also appreciate the benefits resulting from the use of modern electronic tools of communication in education for intellectually disabled people, such as the opportunities to make autonomous choices of decisions, which strengthen their self-esteem and are an important indicator of mental well-being.

Research curiosity is a motivation for the author of this study to go from theoretical discussion to empirical exploration in order to confirm the relationships between using modern electronic means of communication (such as e-learning) in education for people with mild intellectual disability and their mental well-being.

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