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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).

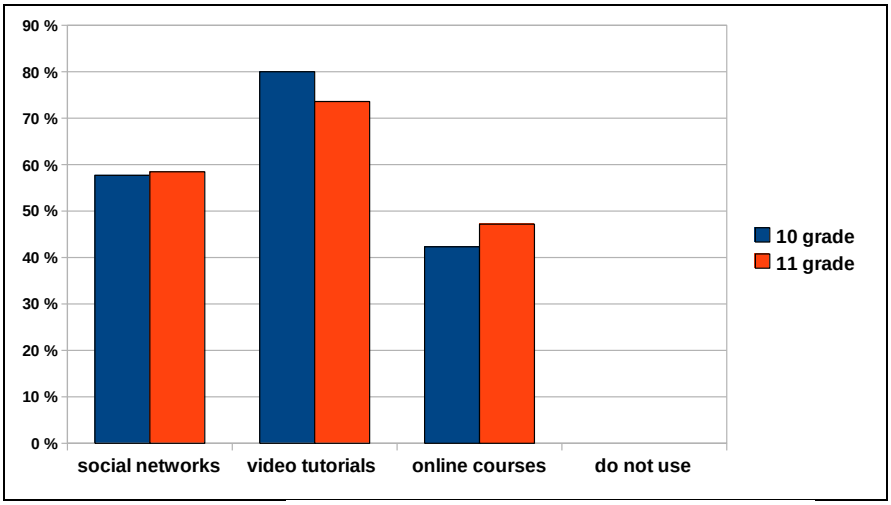

Figure 1. Usage of Internet technologies for self-education
Source: Own work

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).

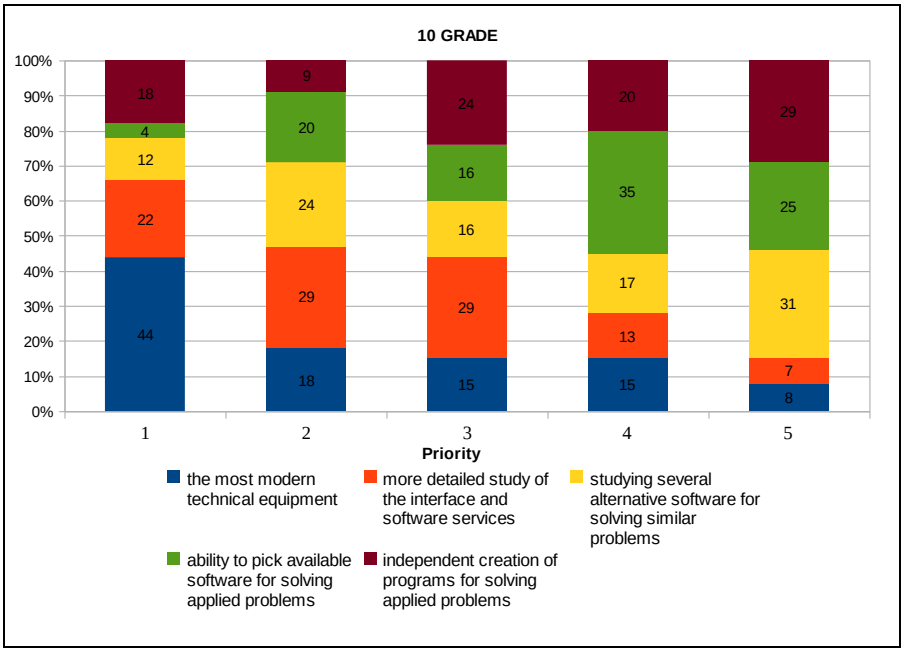

Figure 2. Distribution of priorities of factors that could improve the study of computer science at school by 10 grade students. Priority 1 (highest impact), 5 (lowest impact)
Source: Own work

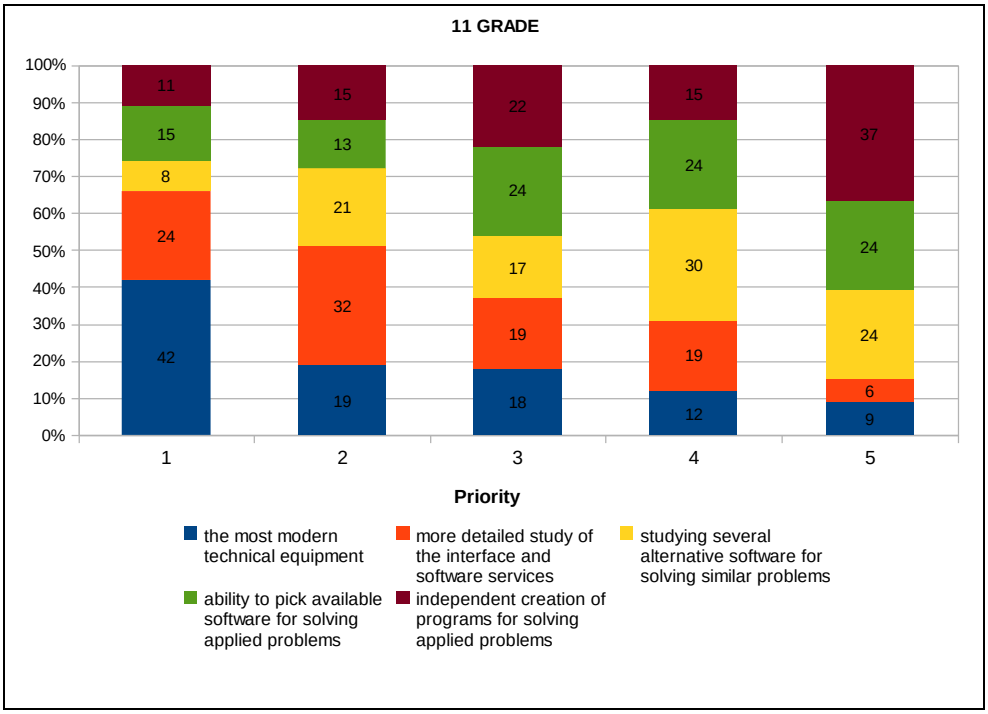

Figure 3. Distribution of priorities of factors that could improve the study of computer science at school by 11 grade students. Priority 1 (highest impact), 5 (lowest impact)

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.

REFERENCES

Hilty, L.M. & Huber, P. (2018) Motivating students on ICT-related study programs to engage with the subject of sustainable development. *International Journal of Sustainability in Higher Education, 19(3),* 642-656. doi:10.1108/IJSHE-02-2017-0027 ISSN: 1467-6370.

Horoshko, Y., & Tsybko, H. (2017). Experience and the prospects of using free software at the teachers' training university. In E.Smyrnova-Trybulska (ed.), *Effective Development of Teacher's Skills in the Area of ICT and E-learning. "*E-learning". 9. (pp. 295–309). Katowice - Cieszyn: Studio Noa for University of Silesia in Katowice. ISSN 2451-3644 (print edition).

Kołodziejczak, B., & Mokwa-Tarnowska, I., & Roszak, M. (2018). Directions on the evolution of higher education. In E.Smyrnova-Trybulska (ed.). *E-learning and Smart Learning Environment for the Preparation of New Generation Specialists. "*E-learning". 10. (pp. 135–152). Katowice - Cieszyn: Studio Noa for University of Silesia in Katowice. ISSN 2451-3644 (print edition).

Korol, O., & Alekseev, O. (2014). Problems of construction of a non-core informatics course for students of different specialties of the Institute of Educational Sciences. *Collection of scientific works of Uman State Pedagogical University. Part 1,* 175-181.

Makasiranondh, W. & Maj, S. & Veal, D. (2011). Student Opinions on their Development of Non-technical Skills in IT Education. *Modern Applied Science.* 5(2). DOI:10.5539/mas.v5n2p3. E-ISSN 1913-1852

Mladenovic, S. & Žanko, Ž. & Mladenovic, M. (2014). Elementary Students' Motivation Towards Informatics Course. *Procedia - Social and Behavioral Sciences.* 174. 10.1016/j.sbspro.2015.01.1113.

Nager, A. & Atkinson, R. D. (2016). The Case for Improving U.S. Computer Science Education (May 31, 2016). *Information technology & innovation foundation.* Retrieved from http://www2.itif.org/2016-computer-science-education.pdf (accessed 28 June 2019).

Olifirov O. V., & Makoveichuk K. O. (2013). Conceptual basics of informatics for the economic and engineering specialties of a non-computer profile. *Business Inform, 8,* 150-155. Retrieved from http://nbuv.gov.ua/UJRN/binf_2013_8_27 (accessed 2 August 2019). [In Ukranian]

Program of Informatics courses 5-9 classes of general educational institutions. (2017). Retrieved from https://mon.gov.ua/ua/osvita/zagalna-serednya-osvita/navchalni-programi/navchalni-programi-5-9-klas (accessed 12 June 2019).

Resolution of the Cabinet of Ministers of Ukraine dated November 23, 2011 No. 1392 "On Approval of the State Standard for Basic and Complete Secondary Education".(2011). Retrieved from https://zakon.rada.gov.ua/laws/show/1392-2011-%D0%BF (accessed 28 June 2019).

Romaniuk, L. (2017). On the problem of using machine translation systems by students of non-linguistic specialties. In N. Petliuchenko (ed.). *Odessa Linguistic Bulletin.* 10(2). (pp. 143-146). Odessa: Phoenics. Retrieved from http://nbuv.gov.ua/UJRN/olinv_2017_10%282%29__34 (accessed 01 August 2019). [In Ukranian]

Smyrnova-Trybulska, E. (2018). Smart university in smart society – some trends. In E. Smyrnova-Trybulska (Ed.). *E-learning and Smart Learning Environment for the Preparation of New Generation Specialists. "*E-learning". 10. (pp. 65–80). Katowice - Cieszyn: Studio Noa for University of Silesia in Katowice. ISSN 2451-3644 (print edition).