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PREPARATION OF FUTURE HUMANITIES TEACHERS FOR THE USE OF STEM TECHNOLOGIES IN PROFESSIONAL ACTIVITIES

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Abstract: *The study analyses the modern views on STEM education and features of the introduction of project activities as one of its directions in the educational process. The influence of the use of STEM technologies on students' motivation is studied; the necessity of preparing students for the implementation of STEM technologies in future professional activities is demonstrated, the results of a survey conducted among future humanities teachers on the mastering of STEM technologies are presented. It was found that STEM education involves the integration of knowledge from different fields, so STEM education can be used in project activities. STEM education allows students to be involved in conscious activities, thus ensuring the success of future adults in the world of digital technology, which is constantly improving. The necessity of including the content module "STEM technologies in foreign languages" in the course "Modern information technologies in the educational process" is substantiated. The tested methodology of training future humanities teachers to use STEM technologies in professional activities is described. It includes independent research of students using STEM technologies and their own creative STEM projects. An example of a STEM project created by students has been given.*

Keywords: STEM education; digital competence; digital technologies; STEM project; teacher.

INTRODUCTION

At the present stage of education development, STEM education is a progressive direction. STEM education allows to develop the personality of pupils and students, their intelligence, research abilities, creative thinking based on scientific methods, mathematical modelling, engineering design. The basis of STEM education is the integration of knowledge from different fields, which allows future professionals to be successful in different fields. Almost all experts note that advanced technologies increase motivation to learn and expand basic knowledge in a particular field.

STEAM education differs from the traditional educational process model. The whole process is centred around the problem, phenomenon or situation, which is being investigated, not around the teacher. The teacher acts as a mentor who helps to find a solution. The main goal of the STEAM approach is to overcome the detachment from solving practical problems. The STEAM approach provides a guide for project activities and a practical orientation, creates conditions for the development and improvement of analytical and creative abilities of an individual, gives an opportunity to try oneself in teamwork, develops independence in acquiring new knowledge. An important concept related to STEM education is interdisciplinarity, which is considered in education as a pedagogical innovation (Morze et al., 2018).

STEM education is traditionally associated with robotics, design, computer modelling and other areas related to engineering rather than the humanities. However, the potential of STEM education as a means of developing the speech competence huge. This is a joint scientific and technical creativity, in the process of which it is necessary to agree, communicate, formulate new ideas; protection of creative projects and research works.

In the period of digital transformation of education, the following main challenges of STEM education can be identified: the need to use innovative STEM methods and STEAM pedagogical approach; the training of specialists in STEM education; the development of methodology of professional self-development of teachers regarding the introduction of STEM technologies.

The main problem in the implementation of STEM education in the educational process is the lack of professional STEM teachers. Of particular interest is the application of the STEM education model in the training of future teachers. Educational programmes for the preparation of future teachers should include courses and modules on STEM studies.

The development and implementation of the methodology for training future teachers for the use of STEM technologies in professional activities will positively affect the quality of the organization of education in the period of digital transformation of education, will contribute to the development of personalised, adaptive and project-based learning, critical thinking and problem-solving skills. Based on our methodology, future teachers will be able to plan, develop, implement and popularize educational STEM projects.

Methods

The study was conducted using the methods of theoretical and empirical research: analysis and synthesis of scientific literature on the research problem to clarify the basic concepts and categories of STEM education; conceptual and comparative analysis of traditional and STEM oriented approaches, curricula and educational programmes, innovative pedagogical experience; identification of patterns and formulation of conclusions on the problem under study; survey of humanities students; analysis of research results.

1. BACKGROUND RESEARCH

The concept of "STEM education" appeared in the United States in 2009 in the programme "Educate to Innovate" (Department, 2009). Official documents from the US Department of Education outline that STEM is an education for global leadership that is designed to shape the critical thinking, research, and engagement with the world that is needed on the way of changes.

STEM education improves divergent and critical thinking, develops students' metacognitive skills, using project-based learning (McAuliffe, 2016; Mutakinati et al., 2018). Schmidt & Fulton show that although aspects of the STEM world can be implemented in existing curricula, the implementation and testing of these innovations requires significant efforts to meet the needs of educational institutions and their full successful implementation (Schmidt, 2019). C. Kim and other authors describe a research project aimed at helping teachers learn to develop and conduct lessons using STEM technologies (Kim, 2019).

According to the Concept of STEM-education, high-quality professional training of future specialists requires the development of educational programmes of educational institutions taking into account the latest pedagogical methods of STEM education, the application of modern network forms of educational communication, the establishing of the interdisciplinary connections, organization of educational process as pedagogical interaction, aimed at personal development, their readiness for solving life problems of varying complexity (Concept of STEM education, 2020). The structure of STEM education in Ukraine is determined by the State standard of general secondary, out-of-school, preschool, higher education and specialized standards of STEM education. Among the main sections in the implementation of STEM education in Ukraine are: higher/professional – training of specialists in various STEM professions on the basis of higher education institutions; and pedagogical – training of teachers to teach STEM educational courses, to implementation, to realization of STEM projects; formation of STEM competences.

According to Strizhak et al., the development of STEM education requires new research, didactic developments, trained, literate and managed professionals who could significantly influence this process. Therefore, it is important to implement initiatives for the training of STEM teachers (Strizhak et al., 2017). Balyk, Barna, Shmyger, & Oleksiuk developed a model of STEM competences for teacher professional training and lifelong learning, which includes four components: problem solving, working

with people, working with technology, and working with an organizational system (Balyk et al., 2018). Andrievska explores a multidisciplinary approach to the study of natural and mathematical disciplines. She considers the project method as the most promising means of implementing STEAM education in the modern primary school (Andrievska, 2017). Possibilities of using elements of STEM education in teaching physics are considered in the research of Atamanchuk & Forkun (Atamanchuk & Forkun, 2019).

The use of certain aspects of IBL is important in STEM education. The authors analyse the advantages and some aspects of STEM education and trends in modern professions with examples (Morze, Smyrnova-Trybulska, & Gladun, 2018).

Morze, Gladun and Dzyuba have analysed modern views on STEM education and features of the implementation of robotics as one of its branches in the educational process, its impact on student motivation (Morze et al., 2018). The authors have demonstrated the need to prepare students for the skills of the twenty-first century through the implementation of STEM education, starting from primary school and have investigated the problem of preparing teachers to conduct classes using robots, integrating them into subjects and selection of robotic designers.

Young people and students should be prepared in the fields of STEM education for successful functioning in digital society as well as for careers in contemporary and future professions which require adequate competences (Basogain, et al., 2020).

The need to prepare students for 21st century skills through STEM education is strong, especially at the elementary level. A modern form of interdisciplinary education for children and youth is projects and master classes, in particular, using kits for designing and programming robots (Smyrnova-Trybulska et al., 2017).

The results of a survey of teachers in Poland and Ukraine show that more than 50% of respondents understand the important role of STEM education and the need to introduce STEM technologies into the educational process.

91 primary school teachers and future teachers of the Silesian Voivodeship and the Silesian University of Poland and Ukraine and the Borys Grinchenko University of Kyiv took part in the study (Smyrnova-Trybulska et al., 2016).

The analysis of research allows us to conclude that there is a lack of scientific works that would reflect the peculiarities of the training of future teachers of the humanities to the use of STEM technologies in professional activities.

2. STEM EDUCATION: THEORETICAL BACKGROUND

Theoretical analysis of sources on STEM education has identified three key features of STEM education that distinguish it from the traditional education system:

- increasing the time and opportunities for independent preparation, the ability to identify problems and find ways to solve them in an autonomous independent manner through active purposeful and conscious activities;
- the opportunity to share one's analytical, creative findings and mistakes with other team members through participation in teamwork;
- mutual support and mutual assistance in solving educational tasks.

One of the key differences between STEM education and traditional learning is the development of learning skills as opposed to learning the material. Independent work, the ability to produce new ideas, teamwork, solving cognitive tasks are also important and necessary. STEM education creates a guarantee of successful further study and development of many areas in professional activities.

A key feature of STEM education, which has already been mentioned, but which should be emphasized, is the interaction during teamwork. Teamwork is especially relevant during the activities in the mode of creation, implementation and protection of projects. Thanks to project activities, the opportunity to activate the creative, emotional and creative component of your personality is realized. Modern education on a global scale is aimed at attracting STEM education in the direction of traditional education. This is due to the fact that STEM education allows you to include the individual in a conscious intense activity, thus ensuring success in the world of information technology, which is constantly improving. All this is possible due to the interdisciplinary applied nature of STEM education. Thus, STEM education is one of the brightest innovations of the 21st century, and it combines elements of innovation pedagogy, art pedagogy, modern pedagogical technologies. The effectiveness of this approach is associated with the practical implementation of the synergy of different fields of knowledge in the process of educating young people.

The main goal of STEM education is to educate a person who is able to independently study large amounts of information, use new technologies and be creative in finding solutions. In this way, the teachers can use the classic formats of work listed above, and can create and come up with their own. Feedback is especially important when introducing STEM education methods into the learning process.

The process of learning a foreign language involves the formation of speech competencies. Therefore, the use of STEM education methods in foreign language classes is very important. This can be the use of language learning applications, such as Quizlet, as well as creating projects and presentations.

STEM education involves the use of digital technologies in the process of learning foreign languages. The advantages of their use are: receiving a large amount of authentic information; influence on all channels of perception due to the use of multimedia technologies (text, graphics, sound, animation, video); game activity.

STEM education is an integral part of the concept of the New Ukrainian School (Ghrynevych, 2016). In the process of research, we have identified the competences of NUS, which have much in common with the goals of STEM:

- development of logical and mathematical thinking;
- understanding of nature and technology from the standpoint of exact sciences;
- ability to use information and communication technologies; ability to think creatively and form one's own opinion.

Combining different sciences and views on reality, STEM education prepares students for life in a rapidly evolving world; easily and quickly adapt to new technologies and trends.

STEM education allows teachers to clearly transfer knowledge and skills, promote student independence, use extraordinary approaches to learning, to form more motivated and interested students. STEM principles can also be implemented in humani-

ties lessons, as STEM tools will diversify the learning process and make the process of acquiring knowledge clearer.

3. RESEARCH

It is important to prepare future teachers in higher education institutions for the introduction of STEM technologies in professional activities.

STEM technologies are STEM education technologies that diversify the activities of the teacher and involve initiating and motivating students for integrated, personally oriented, problem-based, creative and reflective educational activities.

When designing the content and technologies for the implementation of disciplines of the module aimed at the development of STEM technologies, we have identified the main competences that need to be formed in teachers in the process of studying the proposed module:

- ability to acquire new knowledge using modern educational and information technologies;
- ability to independently formulate goals, set specific objectives for research in basic and applied fields of science and solve them using modern research methods using the latest domestic and foreign experience and using digital technologies;
- ability to implement an interdisciplinary approach and implementation of innovative educational technologies; ability to master new theories, models, research methods, skills of developing new methodological approaches taking into account the goals and objectives of the study.

These requirements for the competences of teachers in the field of STEM should be formed during their professional training in higher education, continuing professional development and training.

Preparation of future teachers for the introduction of STEM technologies in professional activities in the context of the development of their digital competence is one of the tasks during the design of digital educational environment of Ternopil Volodymyr Hnatiuk National Pedagogical University (Henseruk, 2020). To implement this task, a strategy for the development of digital competence of future teachers has been developed.

In the context of the purpose of the study, it is important to prepare future humanities teachers for the implementation of STEM technologies in professional activities. Content on the development of digital competence of future specialists of the educational programme "Secondary education. English language" training of the first level of education is built on a structural and logical scheme: Modern information technologies in the educational process → Computer practice → Vocational subjects → Vocational subjects teaching methods → Teaching internship → Course/Bachelor's Project → Elective disciplines in digital literacy.

In this regard, in our opinion, integrated learning is important, which presupposes the readiness of future teachers of the humanities to solve problems related to innovative practical professional activities.

At the first stage of the research, we conducted a survey of students on their understanding and opportunities for the implementation of STEM technologies in professional activities. The survey involved 96 first-year students of the Faculty of Foreign Languages of Ternopil Volodymyr Hnatiuk National Pedagogical University. The questionnaire consisted of 10 questions. The questions involved determining the students' motivation to work with the use of STEM technologies and the level of mastery of STEM technologies. According to the results of testing, 74.8 per cent of students have a low level and 11.7 per cent of students have an average level of motivation to work with the use of STEM technologies. The reason for the low motivation in most of the students' answers was non-acquaintance in the field of STEM technologies. Based on the analysis of questionnaires, we found low and average levels of mastery of STEM technologies.

4. CONTENT MODULE "STEM TECHNOLOGIES IN FOREIGN LANGUAGES"

The next stage of the study was the development of methods for training future teachers to use STEM technologies in professional activities. During the review of the educational program at the meeting of the program council and the quality commission of the Faculty of Foreign Languages, teachers of the course "Modern Information Technologies in Education" were asked to include a content module "STEM technologies in foreign languages" in the curriculum. Based on the analysis of disciplines of this educational program, professionally-oriented disciplines have been singled out, in the process of which STEM technologies will be introduced in cooperation with teachers of the course "Modern information technologies in the educational process". Among the main ones are the following: "Methods of teaching foreign languages", "Practical course of a foreign language", "Lexicology", "Practical grammar and phonetics".

In our study we will dwell in more detail on the rationale for the proven method of training future teachers of the humanities to use STEM technologies in professional activities.

The main tasks of the content module "STEM technologies in the studying of foreign languages" are:

- acquaintance with the peculiarities of the development of STEM education in Ukraine;
- study and generalization of domestic and foreign experience in the field of STEM education;
- study and generalization of domestic and foreign experience in the field of STEM education;
- organization of practical activities of students on the basis of synthesis of artistic and technical creativity;
- implementation of research projects.

In the structure of the educational programme, the module provides general professional training of students. The study is focused on the formation of a system of general pedagogical and special knowledge, which is the basis for the development of

professional competences and the acquisition in the practical training of experience in using STEM technologies in professional activities by future teachers.
When mastering STEM technologies, critical thinking skills and interest in technical disciplines are developed.
Skills of the 21st century is a special area that is now being actively discussed at various levels. Reading, writing, and arithmetic were key skills that determined literacy in the industrial age. In the 21st century, the emphasis is shifted towards the ability to think critically, to interact and communicate, and a creative approach to solving problems. We have combined the basic skills of the future in 4C (Figure 1).
Applying STEM technologies in the educational process, the teacher prepares children for technological innovations of life, teaches them to find creative and innovative approaches in solving various problematic situations.
Project learning is important in the implementation of STEM technologies in the educational process. Its advantages are close connection with the real world, the existence of the problem, a high share of motivation and encouragement to cooperate. The project method forms universal educational skills, gives the chance of independent successful mastering of knowledge, teaches to select, classify, generalize material; to improve public speaking, to see the result of their activities.

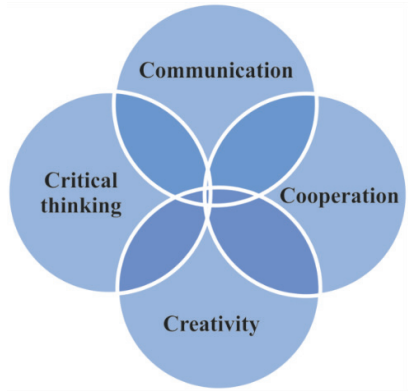

Figure 1. Basic skills 4C
Source: Own work.

Formulation of problematic issues of the educational topic requires work with different sources of information, allows you to express your own opinion with the justification of your own position. All this contributes to the enrichment of the vocabulary and grammar of the language, the development of creative abilities necessary for the modern personality.

4.1. Organisation and content of computer practice

The study of the content module "STEM technologies in foreign languages" took place during a computer practice conducted as part of the course "Modern information technology in the educational process." The curriculum devotes 30 hours of classroom work to computer practice.

The purpose of computer practice is to create STEM projects for learning foreign languages in the context of the development of digital competence of future humanities teachers. Teacher's digital competence is the teacher's mastery in applying digital technologies in their professional activities.

Digital competence includes five dimensions:

- Dimension 1. Information and ability to work with data.
- Dimension 2. Communication and cooperation.
- Dimension 3. Creating digital content.
- Dimension 4. Security. Protection of personal data and confidentiality.
- Dimension 5. Problem solving.

According to the curriculum, computer practice was held during the week (three classes a day), which contributed to the immersion of students in project activities. During the week, students worked in teams and performed both individual and group tasks.

The theme of the projects was the creation of STEM learning projects.

The tasks of computer practice involved forming certain dimensions of digital competence in the context of using STEM technologies, which were prescribed for each day.

As the training took place in a mixed form, we used the Zoom platform during our work. All possible features of the platform were used to organise project activities. During each lesson, group work took place in the Zoom virtual rooms.

The tasks were published in the course "Modern information technologies in the educational process", located in the e-learning system of TNPU. For each task, methodological recommendations and presentations on the use of a specific digital tool were published. Students uploaded all completed tasks to the shared folder on Google Drive (Figure 2):

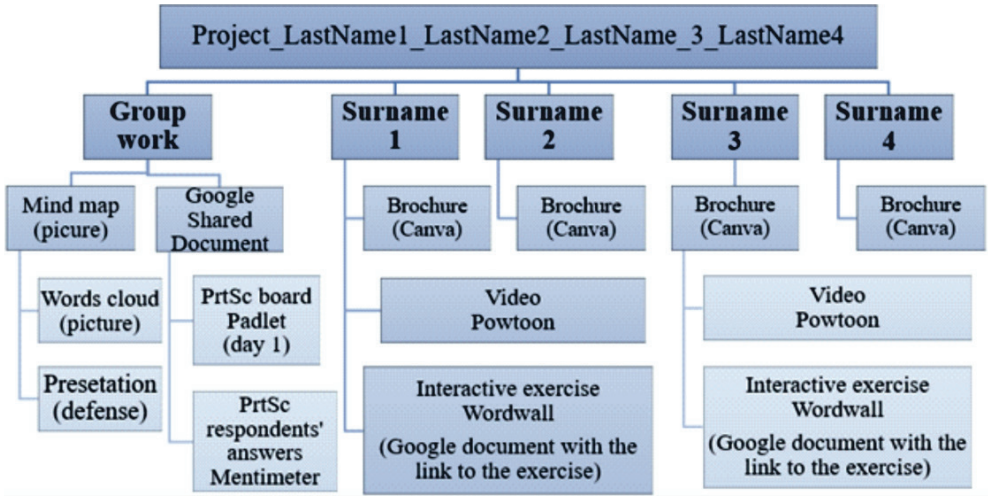

Figure 2. Structural components of the folder

Source: Own work.

Day 1. Choosing a project topic. Search for materials for the project
During the first day, the following dimensions of digital competence were formed in the context of the use of STEM technologies:
Dimension 1. Information and ability to work with data Dimension 2. Communication and cooperation
At the beginning of the project, students had to split into groups (of 4–5 students) and choose the topic of the project in the context of the use of STEM technologies. The next step was to discuss the topic of the project using the interactive whiteboard Padlet (group work). The students had to divide the project topic into four or five subtopics (depending on the number of students in the research group), which covered the whole project topic.
The task of the group work was to create a mind map of their project, which should contain the main topic and four subtopics. Students created a mind map using the digital tool https://www.mindomo.com or https://coggle.it/. Using https://wordart.com/, students created word clouds that represented their project (group work).
During all the following days, all five dimensions of digital competence were formed in the context of the use of STEM technologies.
Day 2–3. Creating digital content.
The tasks of the second day included creating a brochure using Canva (individual work). In the brochure, students had to reveal the essence of their individual research. The active development of digital technologies allows the use of STEM toys, STEM-games, gamified platforms with the aim to develop STEM competences (Wordwall, Mentimeter, Quizlet, LearningApps, Powtoon, Slido, Liveworksheets). The use of STEM games improves practical training. Game technologies make it possible to use the latest technologies; to experiment and solve problems; to immerse the participant in conditions close to real; get acquainted with the peculiarities of project activities, allow you to combine imagination with innovation and contribute to the formation of interest in the subject and further study of STEM technologies.
In this context, the students created an interactive exercise in the group on the topic of their research in the Wordwall resource. The interactive exercise reflected one of the areas of their research.
Interactive animated videos are an excellent tool for qualitative learning, especially in the context of STEM education. With the help of interactive videos, you can concisely and at the same time interestingly and meaningfully convey the key content of the programme material. One of the tasks for the digital content of the developed STEM project was to create an interactive video in the PowToon environment. In the video, students revealed the practical component of their part of the study.
Day 4. Promotion of the project.
Promotion of the project is important at the stage of its implementation. The task of the fourth day was to discuss in a group way to promote the STEM project (group work) using digital tools (Google documents, interactive whiteboards, mind maps).
The opinion of experts is also important for the successful implementation of the project. Experts on students' STEM projects were students of another group. In the context of this task, students created a questionnaire on the topic of their STEM project using the Mentimeter feedback resource.

Day 5. Project defence.
At the last stage of creating STEM projects there was a presentation of the research results (group work). Students presented their project using the created presentation (up to 10 minutes). In the presentation of the STEM project, it was necessary to reveal the practical component of their research (developed resources on the project topic, recommendations, project calculation, etc.). Students created the presentation using selected online resources for creating presentations: Google presentations, Canva, Prezi.

4.2. Project example

As an example of such a project, we will give as an example the STEM project developed by students for learning English "English language courses for children AKMA" (Figure 3).
Students selected digital tools that involve learning a foreign language in the form of games, developed appropriate methodological support using digital tools and project calculations for its implementation.
The implementation of this STEM project in the educational process of educational institutions involves the formation of "4C" skills, which we described above.

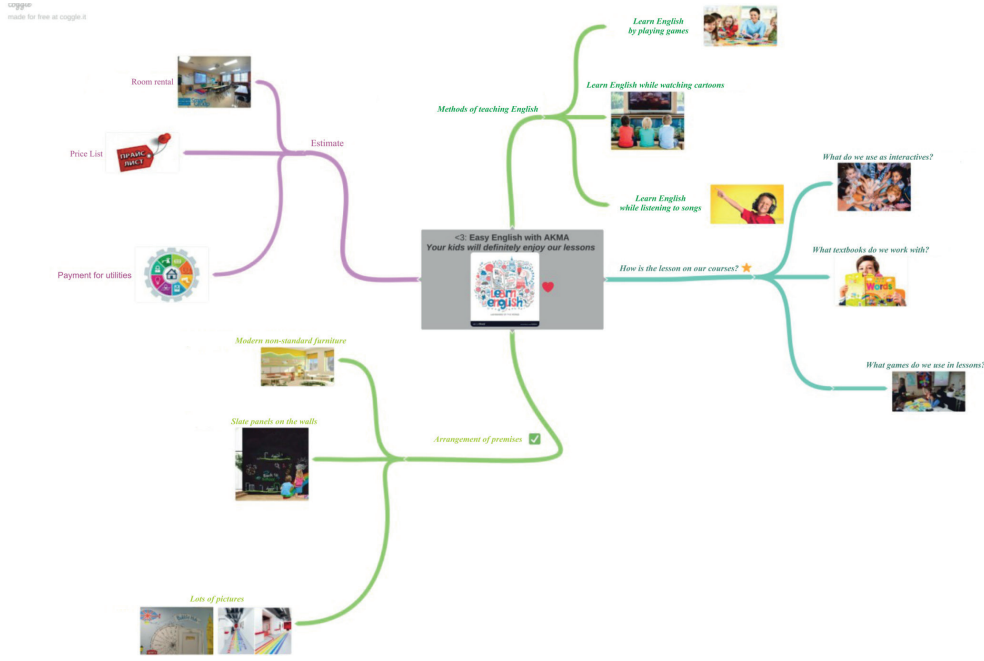

Figure 3. Project knowledge map

Source: Own work.

The proposed method of training future teachers for the use of STEM technologies in professional activities allows forming a specialist with a certain level of digital competence. They will acquire the following STEM learning skills: critical thinking

(A1), problem solving (A2), active communication (A3), collaboration (A4), creativity (A5), Internet safety (A6), innovative approaches to creating projects (A7), creating STEM digital content (A8).

5. SURVEY OF STUDENTS

According to these descriptors, a survey of students was conducted regarding the level of the above skills. The survey was conducted using Google questionnaires. Students could evaluate the formation of their own skills at four levels: low, medium, sufficient and high. According to the results of the survey, it is possible to establish the sufficient level of formation of all descriptors. The lowest score of the sufficient level is to the descriptor A8 (Figure 4).

According to the students, they know many such digital tools. However, it is not easy for them to create STEM digital content from the given problem, since this is the first year of their study under the educational programme and they have not learned the teaching methods of the subject yet.

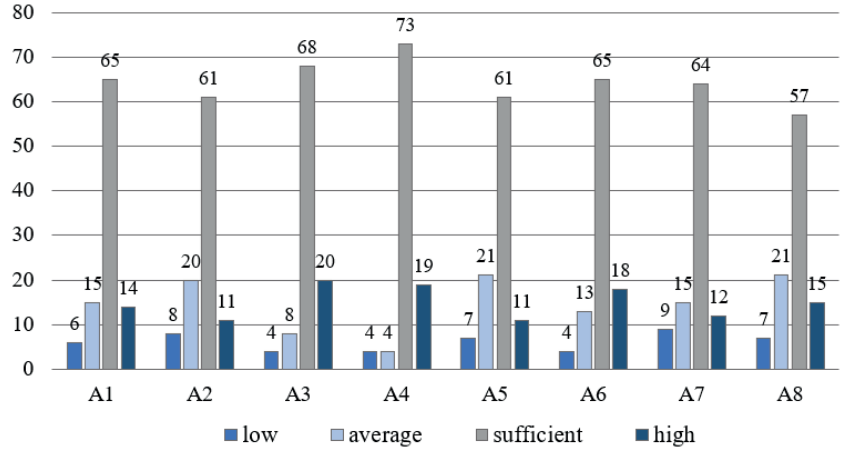

Figure 4. Assessment of the respondents' own STEM learning skills

Source: Own work.

After studying this module, we conducted a re-survey of the possibilities of implementing STEM technologies in professional activities.

Based on the analysis of the questionnaires, it can be stated that there is a significant percentage increase in the number of students who understand the possibilities of implementing STEM technologies in professional activities and have STEM technologies.

According to the survey results, 11.6 per cent of students have a high level and 49.1 per cent of students have a sufficient level of motivation to work with the use of STEM technologies. The survey shows a significant percentage increase in the sufficient and high levels (Figure 5).

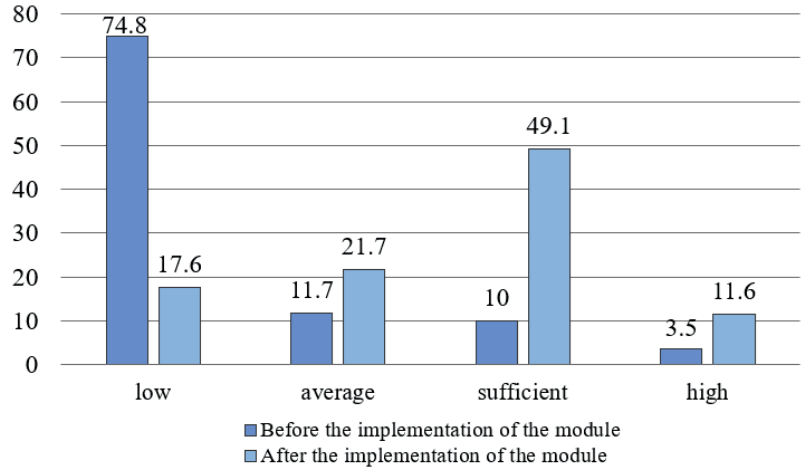

Figure 5. Survey results after the studied module

Source: Own work.

The main purpose of the content module "STEM technologies in foreign languages" was to conduct independent research of students using STEM technologies and their own creative STEM projects. Computer practice classes involved the growth of students' creative skills in the process of research and the creation of STEM-projects.

CONCLUSION

The design and organisation of the educational process based on the development of STEM technologies requires special training of future teachers, which will ensure the mastery of this technology at a high professional level. Therefore, the training module "STEM technologies in the study of foreign languages" should be a necessary component of the main educational programme for the training of future humanities teachers. Mastering STEM learning technologies at the bachelor's level students will create conditions for the diversification of their own pedagogical activity in the future and will allow them to carry out an interdisciplinary approach in work with pupils, and also to use the acquired competences for the organization of pupils' independent activity and development of their digital competence.

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