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Study of the usage of STEM technologies in the context of training Ukrainian teachers of computer science in accordance with the social needs and challenges of today

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Abstract. The article discusses the use of STEM technologies in the training of competitive specialists to meet social needs and challenges in the context of the war in Ukraine. The authors analyse the theoretical foundations and the impact of the STEM approach on modern education, focusing on the introduction of STEM technologies in the process of teaching future computer science teachers. The significance of STEM education as an important trend due to its natural science component and innovative technologies is discussed. The key components of the model of teacher training in STEM are identified, such as target, content, activity, evaluation and result. In order to verify the proposed model, an experimental study was conducted to determine the indicators of students' attitude towards STEM technologies. The necessity of ensuring a high level of teacher qualification for the effective formation of STEM knowledge and skills, as well as solving practical problems of various levels of complexity, is substantiated. The article determines how modern STEM technologies can meet social needs and challenges, especially in times of war. The authors aimed to identify strategies and approaches for the effective use of STEM technologies in education, which will ensure the competitiveness of Ukrainian specialists.

1. Introduction

The development of modern society has led to an increased demand for specialists in high-tech industries. These professionals must possess comprehensive scientific and engineering skills. Currently, these requirements are being met within the STEM educational field, which is recognized as a pedagogical innovation of the 21st century [1, 2]. Against the backdrop of global changes in the modern world, education is becoming a key factor in economic, social, and technological development. Therefore, the development of STEM education (science, technology, engineering, and mathematics) in Ukraine is defined as a priority area aimed at training competitive specialists capable of meeting modern challenges [3, 4].

The development of STEM education in Ukrainian educational institutions has its beginnings in the reforms of the 21st century. The introduction of new standards and programs aims to promote the in-depth study of natural and exact sciences, defining a new paradigm of education.

Interactive methods, laboratory work, and project-based learning are becoming key stages in the formation of scientific and technical competence among the younger generation [5–10].

2. The literature overview

The scientific literature extensively covers the pedagogical challenge of training future STEM teachers [11–14]. However, modern challenges and the needs of the digital society have introduced new qualitative aspects to this issue. These challenges stem from the rapid introduction of technology, the increasing social demands during times of war for technological literacy among all individuals, regardless of their professional orientation, and the growing demand in the labour market for technical and engineering specialists. Integrating STEM technologies into the educational process of educational institutions can address the educational needs of the current generation of young people.

Barlow and Brown [15], Fung [16], Ortiz-Revilla et al. [17] consider various educational approaches to educate young people who can solve real-world problems in line with social needs and the challenges of today while developing skills in advanced technologies. Scientists pay special attention to initiatives aimed at improving STEM education and developing models for education reform. STEM education is most effective when implemented at different levels: formal, non-formal, and informal.

Currently, online elements are crucial in the development of STEM education, allowing students to learn at their own pace and convenience. According to Wu et al. [18], many online educational resources offer interactive and visual components that cannot be replicated in traditional classroom settings.

Researchers in Ukraine are working to improve e-learning STEM courses and platforms to provide more effective and accessible distance STEM education. Barna and Kuzminska [19] highlights the peculiarities of teaching STEM disciplines, specifically the need to use specialized hardware and software. The study analyzes different approaches and presents specific examples of STEM education implementation, including models of traditional, blended, and distance learning. The authors argue for the modification of existing STEM education models to ensure quality education in uncertain conditions. They propose a model of behaviour for STEM teachers that considers the instability of the educational systems.

STEM education is a crucial area of educational reform in the 21st century. Educators face a constant need to adopt new teaching strategies and methods to successfully implement STEM education. According to Buturlina [20], Chen et al. [21], Laursen [22], Lindgren and DeLiema [23], Spirin et al. [24] the definition of STEM education varies significantly among educators, educational researchers, curriculum developers, educational policies, and STEM-oriented learning environments.

The integration of digital technologies, including elements of artificial intelligence, into the educational environment is currently viewed as a promising avenue for enhancing teacher training. According to Papadakis et al. [25], it is important to continue researching the development of appropriate models and design methods. Additionally, the use of an educational environment with elements of artificial intelligence is crucial for implementing these achievements in the educational process.

Creating a favourable STEM educational environment integrates pupils and students into collective interaction and actively introduces modern tools and technologies. The need to develop and implement conceptual and practical frameworks aimed at improving the quality of education in the context of STEM is determined by evidence of this trend. This promotes the emergence and development of effective educational models and methods aimed at improving the effectiveness of their learning [26, 27].

According to Balyk et al. [28], STEM centres are crucial in establishing a conducive environment for STEM education and implementing STEM initiatives. They provide coordination, support, and development for such initiatives. The main functions of a STEM center, according to the authors, include developing and improving STEM programs, providing pedagogical support to teachers for implementing innovative teaching methods and using modern technologies, creating infrastructure to support student research, projects and competitions, and organizing scientific events. All of these functions collectively contribute to the successful implementation of STEM education at the university and the training of highly qualified STEM teachers. STEM centres play a crucial role in fostering innovation and development in STEM education.

Some studies [29–31] focus on enhancing teaching methods and developing better approaches to teaching STEM subjects. STEM education is an academic field that incorporates an augmented natural science component through the use of innovative technologies. According to researchers, the training of future teachers in natural and mathematical disciplines for the implementation of STEM technologies is based on the active use of activities aimed at implementing STEM projects, Learning StartUps, and experiential learning [32–34].

To enhance the effectiveness of STEM students' learning, Hrybiuk [35] investigates the potential of using computer-oriented methodological systems of natural science and mathematics research learning (COMSRL) components to design variable models of research learning. The author's experimental research confirms that the use of COMSRL contributes to the optimal concentration of educational resources and the integration of proven robotics courses into the educational process and extracurricular activities. The organization of content and STEM technologies aims to prepare students for research work and their industrial integration in the educational process. The experiment results identified the most effective psycho-pedagogical factors that influence STEM knowledge acquisition. When considering the feasibility of applying and selecting COMSRL components, the author recommends giving preference to those that contribute to the development of conceptual knowledge structures in students.

The scientific and theoretical foundations of using robotics in education are discussed by Morze and Strutynska [36]. They acknowledge the significance of incorporating educational robotics in STEAM education to enhance students' STEM competencies. This approach prepares individuals for implementing socially significant projects, enhances the practical value of theoretical knowledge, broadens scientific outlook, and promotes successful adaptation in a digital society. The authors have identified a set of STEM competencies necessary for successfully applying robotics in students' future professional activities. According to the researchers, the most important competencies are integral STEAM competence in the field of robotics, research competence, digital competence, and soft skills.

Stimulating social interaction among future teachers in a professional environment is an essential aspect of the learning process. This facilitates the formation of collective experience, the exchange of ideas, and the sharing of best creative practices in STEM education [37]. During their training, the interdisciplinary aspects of STEM/STEAM education [38] are emphasized. Various complex methodological support and elements of STEM technologies, such as robotics [39], microcontrollers [40], embedded systems [41], 3D technologies [42], 3D printing [43], artificial intelligence [44], machine learning [45], drone science, or the study of drones (unmanned aerial vehicles) [46], VR [47], and AR [48] are used in the educational process. This enables the preparation of specialists for modern challenges and the implementation of STEM technologies in various educational institutions.

Significant progress has been made in researching the theoretical and methodological foundations of STEM education, including the design of immersive technologies. Immersive technologies are a significant component of STEM technologies, providing innovative tools for learning and research in various fields [49–52].

The new generation of educational systems is characterized by a higher level of adaptability compared to previous automated learning tools [53]. This is accomplished by creating a

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flexible and open educational environment that utilises hybrid cloud solutions, augmented and virtual reality technologies, and elements of artificial intelligence [54]. These technologies offer personalised services at both the individual and collective levels.

Semerikov et al. [55] analyse various approaches to understanding concepts such as "immersiveness", "immersive educational environment", "immersive approach in education", and "immersive educational resources" (IER). Authors consider the pedagogical aspects of using immersive environments in teaching and classify research on immersive education. Additionally, this paper analyses the key elements involved in designing and implementing multimedia electronic displays (MED). It defines the fundamental principles of MED design and outlines the methodology for its implementation in educational settings. The paper also examines the general model of the methodology for designing IERs, which includes the goals, objects, methods, stages, and content of training, as well as the forms of organization of the educational process, teaching aids, and expected results of the methodology. The article proposes elements for designing immersive educational resources, specifically a comprehensive immersive educational development in the form of a distance course. It also considers examples of designing prototypes of immersive learning materials and other innovative approaches.

According to the literature analysis [56–58], the use of AR and VR in STEM education provides numerous opportunities for learning concepts and acquiring scientific skills. At the same time, it is necessary to balance the positive effects of these innovative technologies with the related risks to enable a critical and conscious use of them. These works provide a methodological basis for further research in this area, particularly in the context of using STEM technologies for the professional development of teaching staff.

3. Theoretical background

The training of future school teachers is crucial for many European countries, including Ukraine. Ukrainian universities acknowledge the significance of training highly qualified STEM professionals and are adopting innovative teaching approaches. An urgent task is the development and implementation of new bachelor's and master's programmes aimed at enhancing research skills.

The research focus of this article is to study the use of STEM technologies in the context of training competitive specialists to the social needs and challenges of today. The results of the study can serve as a basis for further discussions and improvement of educational practices aimed at forming specialists who can effectively cope with modern social challenges and needs.

The research goal is to study the main trends in university STEM education; to identify the key components of the model of training teachers in STEM, to study the use of STEM technologies in the context of training competitive specialists by the social needs and challenges of today in times of war.

Research methods. The research methodology covers various aspects of the use of STEM technologies in the process of training competitive specialists. The authors used the following research methods: analysis of primary sources, designing a model for STEM-oriented training of future computer science teachers, a questionnaire to determine the effectiveness of using STEM technologies in training competitive specialists, and factor analysis to identify the mutual influence of the model components.

The main trends in Ukrainian university STEM education are as follows.

- Virtual laboratories. There, students can conduct experiments and research in an online environment, developing skills and knowledge without the constraints of traditional laboratory conditions.
- Interdisciplinary integrated courses. They combine elements of various STEM disciplines to promote integrated learning and the development of complex solutions;

- Cooperation with world universities. The organisation of joint programmes and projects with global universities provides an opportunity to create an international environment for learning and exchange of experience.
- Robotics and drone programming. This approach is implemented through courses and workshops on robotics and drone programming to teach students modern technological and engineering skills.
- STEM projects with a social focus. The implementation of such projects is aimed at solving social problems using STEM technologies, which contributes to the development of responsibility and social awareness of students.
- STEM laboratories and STEM centres. In these centres, students can use advanced equipment and technologies for their own research and projects.
- Internships and employment in IT companies. The organisation of internships and practice programmes for students in large IT companies enables future specialists to apply theoretical knowledge in practice.
- STEM mentoring programmes. This approach involves providing support from experienced STEM professionals and guiding students in developing their professional skills;
- STEM incubators and start-up centres. The trend is implemented by creating an infrastructure for start-ups and innovations, where students can implement their ideas and develop their own STEM projects.
- STEM festivals and conferences. These are places where students can demonstrate their achievements, share experiences and interact with representatives of well-known companies and academic institutions.

These ideas aim to encourage a creative approach to STEM education in Ukrainian universities and promote student innovation in these fields. The introduction of STEM education in educational institutions has resulted in increased student interest in the natural sciences, as well as an increase in the number of university problem groups and competitions. STEM laboratories, technology parks, and educational centres provide opportunities for in-depth study of subjects, experimentation, and a creative approach to learning.

Ternopil Volodymyr Hnatiuk National Pedagogical University (Ukraine) is also implementing STEM approaches in its educational process. The Faculty of Physics and Mathematics trains future computer science teachers using STEM approaches, and there is a STEM centre to support STEM disciplines.

We propose the model for future computer science teacher training in STEM at Ternopil Volodymyr Hnatiuk National Pedagogical University. The key components of the model are follow:

- Educational training. This component covers professional education, including educational bachelor‘s and master‘s programmes “Secondary Education (Informatics, Mathematics, STEM Education)”. Teachers with interdisciplinary knowledge in various STEM fields can more easily integrate different subjects and create more holistic lessons.
- Pedagogical skills. This element focuses on the development and use of effective teaching methods that stimulate interest in STEM subjects. Innovative pedagogical approaches, such as project-based learning, robotics, and game-based approaches, are also discussed.
- Preparation for the use of technology. It involves training teachers in the use of modern technologies to improve the learning process and engage students, as well as developing digital skills for students to effectively use information and communication technologies.
- Support for research activities. The component includes the stimulation of scientific research through the creation of a STEM research centre, support for future teachers in conducting

research in their chosen STEM field, and involvement of students in scientific and practical projects.

- Cooperation with the public and various institutions. It is essential to increase the intensity of communications on STEM education, promote ideas about STEM education among the public, and facilitate the professional development of teaching staff and specialists involved in the educational process.

These components create a model of teacher training in STEM to form highly qualified teachers capable of stimulating students' interest in science and technology (figure 1).

During wartime, the authors adapted and modernised the curricula of bachelor's and master's degree programmes, identified the current state of STEM curricula, and highlighted key topics that need to be adapted to the war. The theoretical material was updated to accommodate limited resources, and practical examples from real life were added. Here are examples of specific courses, STEM technologies and methodologies that have been introduced into the educational process.

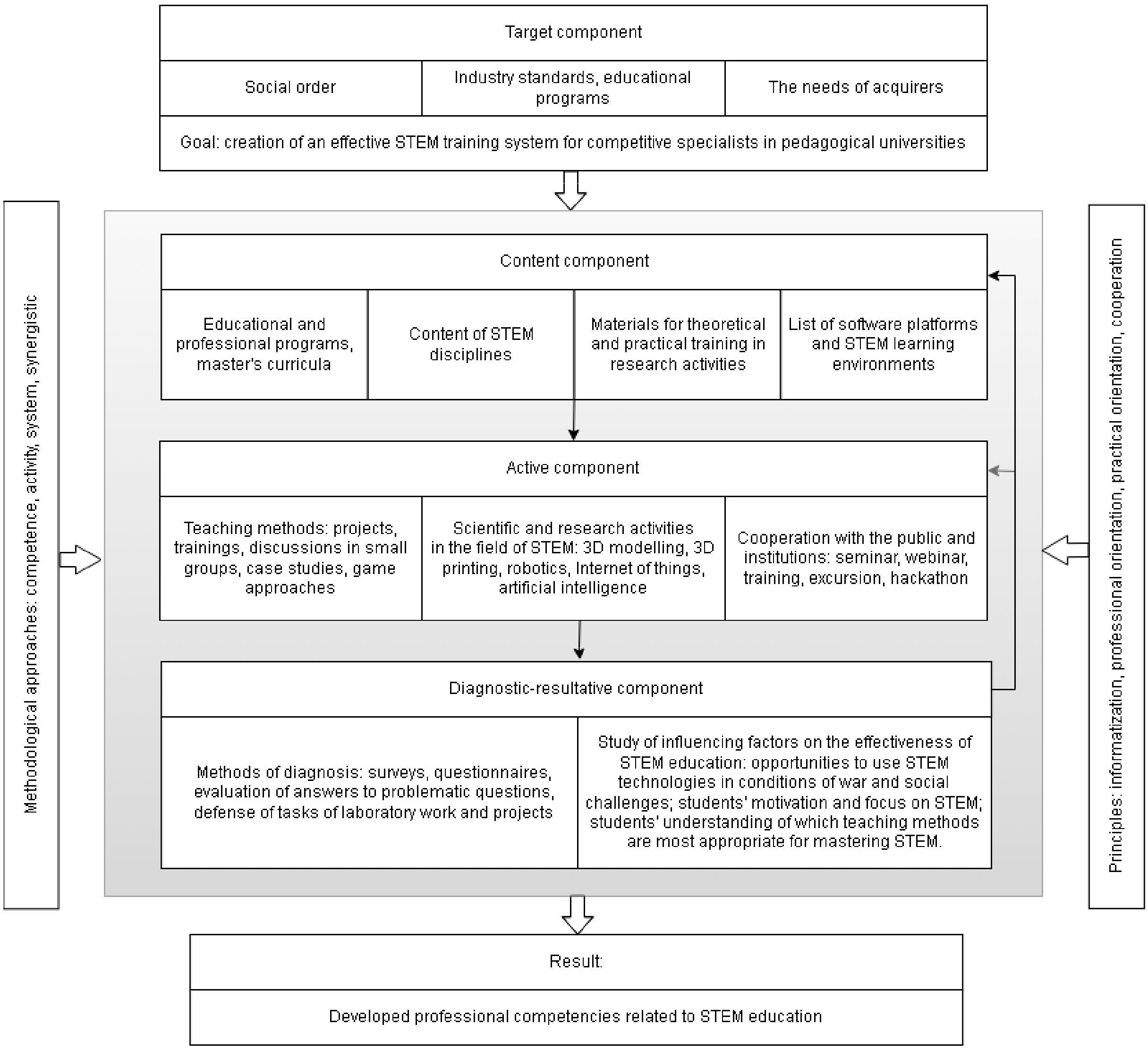

Figure 1. A model for STEM-oriented training of future computer science teachers.

Courses offered include "Methods of Teaching Computer Science and STEM Education Technologies", "STEM Projects", "Fundamentals of Robotics", "Fundamentals of Cybersecurity", "3D Modelling", "3D Printing", and "Computer Networks". *STEM technologies* covered include programming, 3D modelling and 3D printing, robotics, IoT, virtual reality, artificial intelligence, and VR/AR.

Educational, methodological and technical support for STEM education are e-courses "STEM projects", "Methods of teaching computer science and STEM technologies", "Fundamentals of robotics", "E-learning technologies"; technical equipment of the STEM centre.

Methods of conducting classes. Creative teaching methods: stimulation of creativity, development of students' creative skills in solving practical tasks, projects, search and implementation of methods that promote the development of students' creative abilities, use of alternative materials for practical demonstrations, methods of developing critical thinking.

4. Study results and statistical processing

To investigate the effectiveness of using STEM technologies in training competitive specialists, we created a questionnaire. The respondents were 45 first- and second-year master's students enrolled in the "Secondary Education (Computer Science, Mathematics, STEM Education)" program. Of these, 48.9% were female and 51.1% were male.

The questionnaire comprised multiple question groups. They were formed in the form of a 5-item Likert scale and determined indicators of students' use or attitude towards STEM technologies, such as:

- frequency of use of STEM technologies such as programming, robotics, 3D printing, and IoT;
- the benefits of using STEM for gaining knowledge, developing practical skills, innovation, creativity, and critical thinking; difficulties in using STEM, including lack of time and lack of interest or knowledge;
- the effectiveness of using didactic methods in STEM education; Relevance of some STEM technologies (programming, robotics, 3D printing, IoT, aerospace devices) for solving problems related to war;
- students' goals in studying STEM, including getting some knowledge, skills development, having fun, and getting a degree;
- using STEM in future professional activities including for teaching, scientific or practical work, to solve some social problems and to develop own career.

To reduce the number of variables in the factor analysis, average values were calculated for the variables listed above. The survey data can be accessed via URL: `https://drive.google.com/file/d/188vI7AzyGo-eYsDoHzTswULBAuQgKuB6/view`.

Exploratory factor analysis was used to verify the selection of criteria groups [59]. This method can also reveal other factors, such as latent correlations between certain indicators in the survey. This means that the variance of a large number of variables in our dataset can be described by a few summary variables, i.e. factors [60]. It is assumed that some of the latent variables coincide with the question groups in the survey. The search steps are repeated until a smaller number of factors is reached. The statistical data was processed using libraries from the R language, such as psych, nFactors, and corrplot.

From the CSV file in the sel_data dataset, we selected the required fields (AverageScoreSem, FrequencyUsingSTEM, LevelMasterySTEM, InterestInSTEM, AdvantagesUsingSTEM, SelfReadinessUsingSTEMSolveProblemsRelatedWar, STEMImportanceOvercomingWarConsequences, EffectivenessTeachingMethodsSTEM, UsingSTEMInFutureProfessionalActivities).

Then, the eigenvalues were calculated from the sel_data numerical dataset (list) which was processed as a correlations vector. Using the fa.parallel() function, we analysed the number

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of factors to be retained in the subsequent factor analysis. Factors with an eigenvalue greater than or equal to two were selected as significant. There were 3 such factors. Additionally, the dependence of the number of factors on the eigenvalues from the vector of correlations is shown in figure 2.

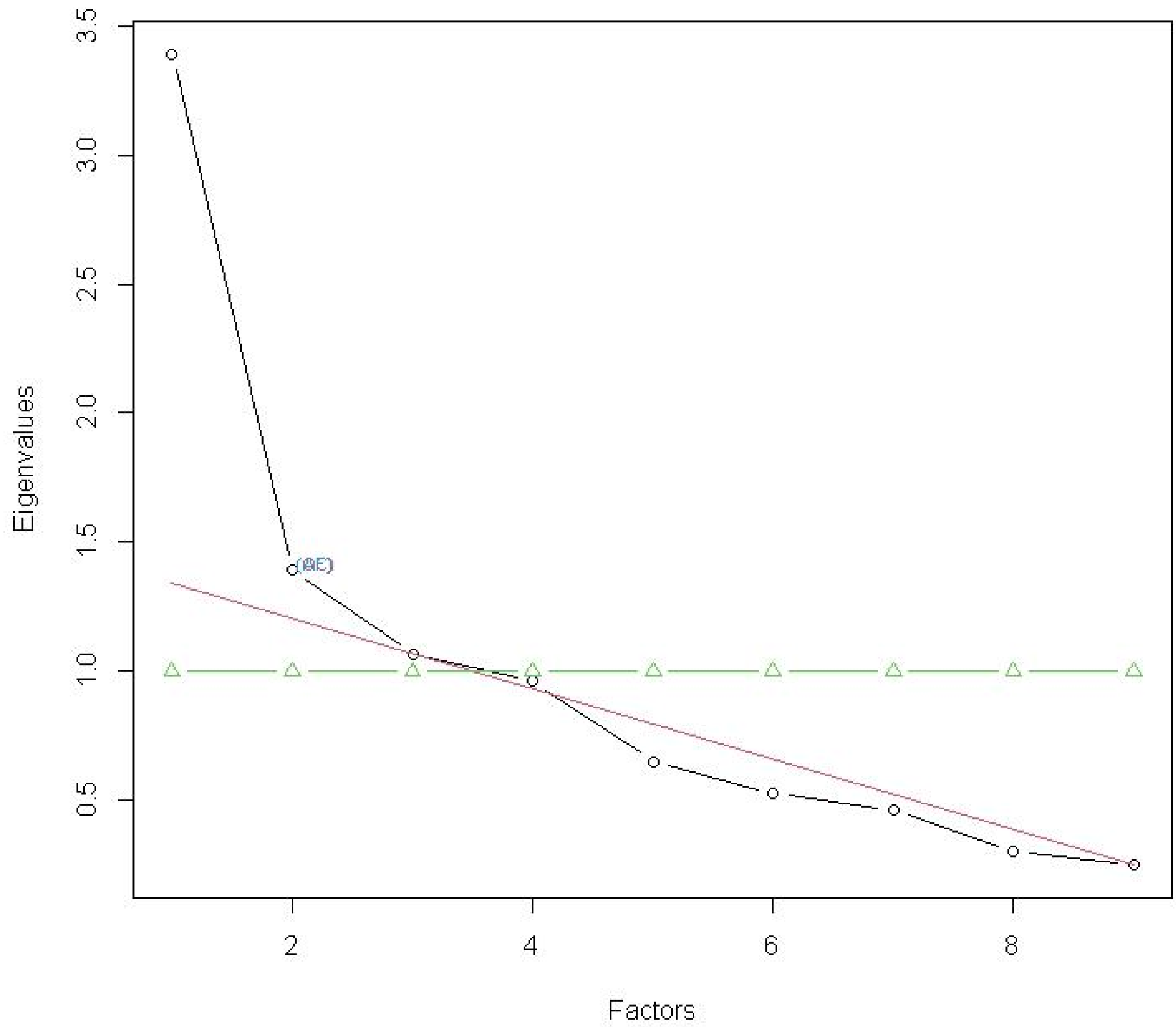

Figure 2. Determining the number of factors to analyse.

If we look at figure 2, the black line shows the eigenvalues of the actual data, while the green and red lines show the modelled and sampled data. Here we can see the large drops in the actual data and the point where they intersect. The gap between the modelled and actual data tends to be minimal near the point $x = 3$. This is the desired minimal number of factors. The graphical method indicates that a four-factor model is also acceptable. However, based on the eigenvalues, we will concentrate on three factors.

To conduct the factor analysis, we utilized the factanal() function from the psych package [61]. The code used for performing factor analysis on the three-factor model is shown below.

```
fit<-factanal(sel_data,3,rotation = ''oblimin'')
print(fit, digits=2,cutoff=0.33,sort=T)
```

The function's arguments were utilised, with 'sel_data' representing the correlation matrix,

’3’ indicating the number of factors to extract, ’oblimin’ as the rotation method (it is assumed that there is a correlation between the factors). The obtained results are presented in the table 1.

Table 1. The results of factor analysis using method maximum likelihood

Variable	Factor ML1	Factor ML2	Factor ML3
FrequencyUsingSTEM			0.50
LevelMasterySTEM			0.67
InterestInSTEM			0.76
AdvantagesUsingSTEM			0.65
UsingSTEMInFutureProfessionalActivities			0.66
STEMImportanceOvercomingWarConsequences	0.57		
SelfRreadinessUsingSTEMSolveProblemsRelatedWar	1.00		
EffectivenessTeachingMethodsSTEM		0.99	
AverageScoreSem			

We can see that our model is simple because it requires a single load of each variable. The last section of the factanal() function output shows the results of a hypothesis test. The null hypothesis, H0, is that the three factors in our model are sufficient to capture the full dimensionality of the data set. In our case, the p-value exceeds 0.75, which is greater than 0.05.

Therefore, we have no reason to reject the null hypothesis. In the three-factor model, the variable AverageScoreSem from the last row of the table 1 is insignificant. This indicates that there is no relationship between the use of STEM technologies in education, students’ attitudes towards STEM technologies and their academic performance. This variable also gives a large uniqueness, sometimes referred to as noise, which corresponds to the proportion of variability that cannot be explained by a linear combination of the factors [62]. It is therefore not included in the model.

The first factor (ML1) consists of two variables. It relates to the war that is currently taking place in Ukraine. Students see opportunities to use STEM technologies in these difficult conditions. It can be reasonably assumed that they know what projects and skills need to be developed in students now. In addition, they must be ready to use STEM technologies in the process of rebuilding Ukraine. The second variable that forms the factor indicates the civic position of students, and their willingness to resist the occupiers.

The variable EffectivenessTeachingMethodsSTEM forms the second factor (ML2) of the model. We interpret it as responsible for creating an educational environment. We call it the STEM ecosystem. This factor demonstrates students’ understanding of which teaching methods are most appropriate for mastering STEM.

Five variables such as FrequencyUsingSTEM, LevelMasterySTEM, InterestInSTEM, AdvantagesUsingSTEM and UsingSTEMInFutureProfessionalActivities form third factor (ML3). This factor describes students’ motivation and focus on STEM. It indicates their interest, understanding of the benefits and readiness to use relevant technologies.

Thus, as a result of the analysis, we highlight the following factors:

- Factor ML1: The value and importance of STEM to solving problems related to war.
- Factor ML2: Effectiveness of the STEM teaching model and methods implemented by the university.
- Factor ML3: Development and application of professional competencies related to STEM education.

In general, all factors show that modern STEM education must meet the challenges of today. We processed the sel_data list using the function fa.

```
ml3<-fa(sel_data, nfactors = 3,
        rotate = 'oblimin', fm = 'ml')
```

We obtained similar data on the number of factors and the distribution of variables within them. The same function returned data indicating the statistical adequacy of our model, such as

- RMSR=0.05. It is the root mean the square of residuals. This is acceptable as this value should be closer to 0.
- RMSEA $\leq$ 0.001. It is the root mean square error of approximation. Its value shows a good model fit as it is below 0.05.
- TLI=1.15 (the Tucker-Lewis index). This is an acceptable value because it exceeds 0.9.

Visualisation of the relationships between the factors of our model was obtained using the fa.diagram() function. It is shown in figure 3.

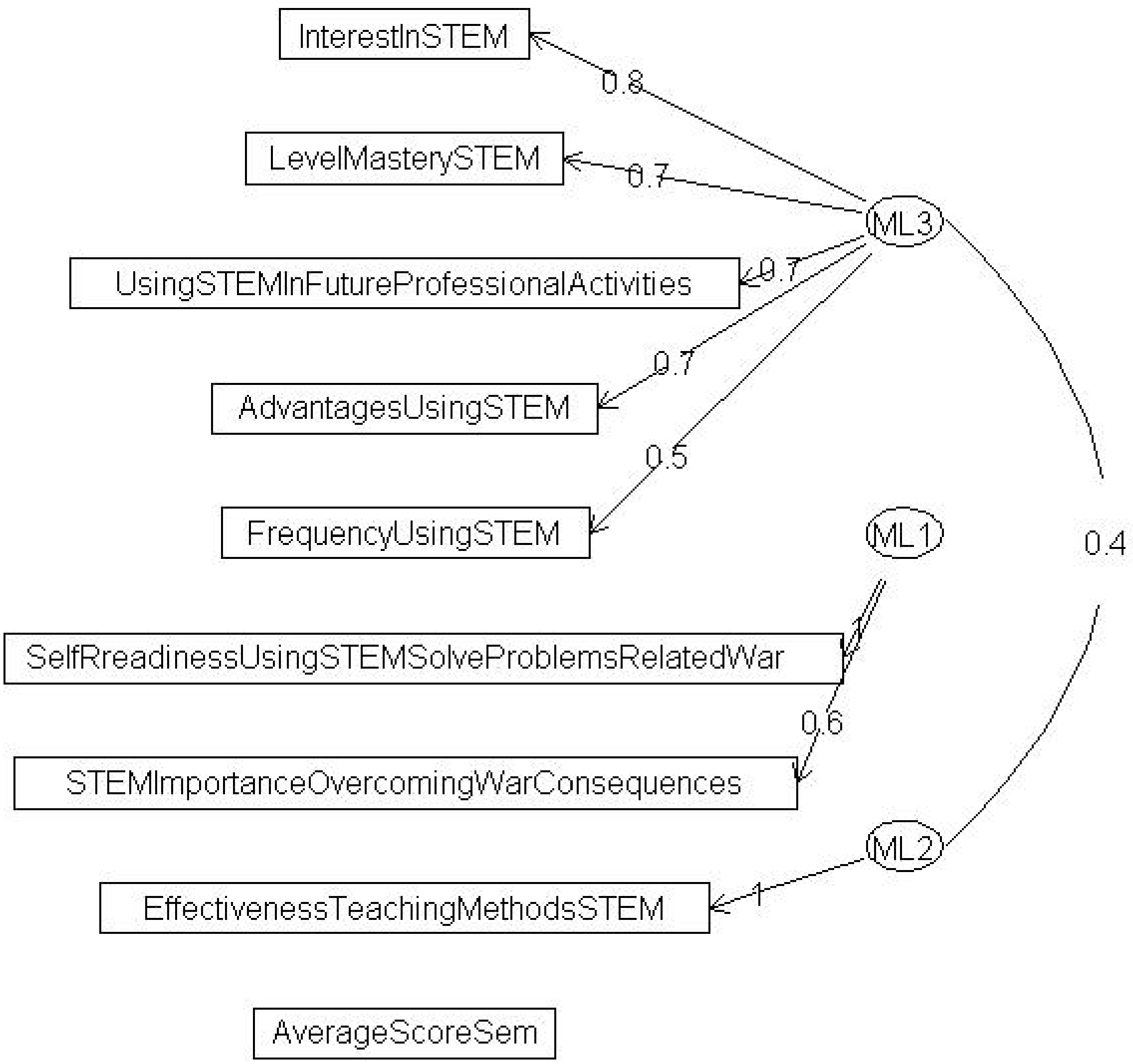

Figure 3. Relationships between the factors of the model.

5. Discussion

In today's world, the issue of training competitive specialists is becoming a critical task for educational institutions. In this context, great importance is attached to the use of STEM technologies as modern pedagogical tools aimed at improving the efficiency of the educational process. Based on the developed model for future computer science teacher training in STEM (figure 1), we can state that the factors identified through the questionnaire have some relationships to the components of the model. Let's analyze these relationships.

Factor 1 (ML1) captures students' wartime experiences and their understanding of the role of STEM technologies in Ukraine's current situation. It combines students' opportunities to use STEM technologies in these difficult conditions and their civic position and willingness to resist the occupiers. In particular, this factor aligns with the social order in the Target component of the model. It considers industry standards, educational programs and the needs of acquirers. In the context of Ukraine's wartime situation, STEM education must equip future teachers with the skills to address the country's specific needs and challenges. Therefore, we offer students to master technologies that ensure the resistance of Ukrainians, such as robotics, drones, 3D printing, etc. The content component of our model emphasizes the importance of content that aligns with educational and professional programs as well as the content of STEM disciplines. The first factor (ML1) highlights the need to integrate the wartime context and the role of STEM technologies into the curriculums. This factor connects to the teaching methods from the Active component, which emphasizes project-based learning, scientific research activities, and cooperative learning approaches. Experiences working on real-world problems, which could address the challenges Ukraine faces, could be a powerful way to engage students. The first factor (ML1) does not directly connect to the assessment methods outlined in the model. However, student experiences during wartime could be a valuable source of data to inform the development of curriculum and teaching methods.

Factor 2 (ML2) focuses on effective teaching methods of STEM disciplines. It aligns with the model's Content component and Active component which emphasize effective teaching methods for STEM education. The model suggests that the content of STEM education programs should include scientific research and practical training activities. Factor 2 highlights the need for teachers to understand how to use these methods to create an effective learning environment. The second factor directly relates to the teaching methods, which outlines specific methods for STEM instruction such as project-based learning and scientific research activities. The diagnostic and result component of the model identifies methods for diagnosing the effectiveness of STEM education, including surveys and evaluation of student work. These methods could be used to assess students' understanding of how to create an effective STEM learning environment.

The factor 3 (ML3) captures students' motivation and focus on STEM. It aligns with the model's overall goal of training competitive specialists and the content component's emphasis on educational and professional programs. Students' motivation and focus on STEM are important indicators of their potential to be successful teachers The model suggests the content of STEM education programs should be tailored to student interests. Understanding students' existing motivation and STEM focus can inform new curriculum development. The model suggests using of active learning methods such as project-based learning. Students who are more motivated and interested in STEM are more likely to benefit from these types of activities. This is evidenced by the value of LevelMastery STEM variable. The diagnostic and result component of the model allows the use of various sets of methods for diagnosing the effectiveness of STEM education, including surveys and evaluation of student work. These methods could be used to measure student motivation, they learning progress and STEM focus.

In accordance with it, we have changed the educational programmes, the content of individual modules, the requirements for students' skills, and the organisation of the educational process itself. The main objective of the model is to make education relevant to our time. In this context, there are some ways to improve the educational process through the introduction of STEM technologies in the training of future teachers. For example, they include the following

- expanding the experience of using Learning StartUps to increase students' motivation for other disciplines, such as programming, information technology, robotics, etc;
- studying gender equality, namely the wide involvement of girls and women in the IT sector, in particular in STEM education;
- inclusion in the design of art and design components of a scientifically based methodological system for teaching various disciplines, including the basics of robotics and 3D technology, as a component of STEM education;
- inclusion of certain components of Learning StartUp in the student's graduation work.

6. Conclusions

The war in Ukraine is a global challenge to democracy, food security, economic stability and international law and order. It has stimulated the development of technology in Ukraine, particularly in the areas of defence, energy, medicine and information security. A successful response to these challenges requires specialists who not only have deep knowledge in their field, but are also capable of interdisciplinary cooperation, data analysis, use of modern technologies and creative solutions.

One way to train such specialists is to use STEM technologies in higher education. For future computer science teachers, we recommend learning the basics of robotics, programming, 3D modelling, drone technology, etc. Ukrainian students should take part in research projects aimed at developing new technologies for the army, infrastructure rehabilitation, energy efficiency, healthcare, etc. Thus, STEM technologies can contribute to the training of competitive professionals who will help overcome the social challenges associated with the war in Ukraine.

The results of this study demonstrate the effectiveness of the STEM teacher training model and the use of the latest pedagogical methods. This approach makes it possible to identify effective learning and skills development strategies that will provide graduates with the ability to innovatively solve problems of varying levels of complexity, given the high level of qualification requirements and the demands of society. As a result of the synthesis and generalisation of the analytical work, recommendations have been developed on the areas of application of modern advanced STEM technologies for the training and professional development of computer science teachers. The results of the study can serve as a basis for further discussion and improvement of educational practices aimed at training specialists who can effectively cope with modern social challenges and needs.

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