TRAINING FUTURE TEACHERS IN A STEM APPROACH

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Abstract. Economies have been developing quite intensively in recent years, especially in terms of technology, which leads to the need to adequately develop education. Almost everywhere in the world, new approaches to modern teaching are being sought in order to help students acquire not only knowledge and skills, but also competencies. One of the modern methodological methods that has proven its effectiveness is the STEM approach. In addition to analyzing the challenges of its implementation, the article shows how and to what extent the preparation of future mathematics teachers is changing in this direction. A comparison of the curricula in Bulgarian higher education institutions regarding STEM preparation classes and the relevant conclusions that can contribute to improving methodological preparation are made.

Key Words: *STEM, higher education, teacher training, methodology*

There is a growing demand across industries for engineering and technological expertise, which makes it of paramount importance to adequately prepare students for their successful and rapid implementation in the labor market. But, on the other hand, it is of utmost importance that teachers are well prepared in methodological and professional terms for this challenge, to have experience and confidence in its application. Naturally, the question arises as to who is responsible for training future teachers in the STEM approach, and whether they have sufficient preparation for confident and effective teaching in this direction. The real reason for the introduction of STEM into education is related to economic needs – the need to train specialists for a new technological society. In order to meet these needs, education seeks to align with these developments. Political documents and strategies emphasize the need to adapt the goals of science education to modern reality [7, 8, 9].

STEM education is seen as a potentially effective tool for preparing students for an increasingly complex world, where they must be able to solve increasingly complex problems. One of the key aspects is attracting more students and teachers to STEM education through a global approach, as well as changes in curricula and teaching methodologies, including replacing the paradigm of education and training, such as to improve the quality of education. The goal is to develop students' skills in technological and engineering skills, competencies for rapid implementation, combinatorial thinking, soft skills that meet the needs of the labor market, in general, the upbringing of functional literacy. But in order to achieve this, it is essential to ensure that teachers are well-prepared [5]. Effective STEM education is closely linked to teacher professional development (TPD) quality [4].

When introducing the STEM approach into education, we must also note the difficulties that are encountered, which are:

- *The need for well-equipped classrooms or spaces.*

  This is provided to some extent in the Bulgarian education system, but only in secondary schools. Not in universities.

- *Developed teaching methodologies that have a proven effect.*

  A significant part of teachers use access to well-developed materials on the Internet. But to what extent is it tested and corresponds to our national curricula.

- *Training teachers who are motivated to implement this type of training.*

  A different attitude and methodological approach to teaching is required. In a significant part of the teaching methodology in the STEM approach, soft skills are also required in addition to professional skills. Teamwork and the creation of a PME are essential.

- A well-developed *system of projects* that are appropriate for the age group, but also consistent with the DES in the relevant subjects. It is also essential that these projects correspond to the interests of the students.

- An adequate *assessment system*. This is shared by the teachers The five components listed are inextricably linked and equal in weight. Each has its own weight and significance.

But let's focus on the preparation of teachers, and to a significant extent on students who are now being trained to enter the teaching profession. To this end, recent studies indicate showing the difficulties that teachers face in implementing the STEM approach. Despite the growing interest not only in society, but also among students, teachers encounter significant challenges in implementing STEM initiatives in the classroom. Some of the main difficulties include:

- Lack of basic and prior knowledge and understanding of STEM.

Research shows that both future teachers in primary education and those in secondary education have low levels of prior knowledge about the importance of the methodology and how to prepare for implementing the STEM approach. A high percentage (over 67%) of mathematics students, apart from M - mathematics, do not know how to interpret the other components, and only 4% have an idea about the teaching methodology. Even after taking an elective, they say they don't feel confident (71%) that they can deliver a full STEM education [2].

- Difficulties integrating subjects.

Incorporating multiple subjects into STEM education is a challenge for teachers, especially when collaborating across subject areas. Teachers often find it difficult to incorporate engineering (E) and science (S) into STEM projects. When surveyed, math teachers reported that their role in STEM projects is limited to basic arithmetic and that they cannot incorporate the topics they are studying into such projects [3].

- Time for planning between teachers from different subjects and for smooth delivery of instruction.

Pressure from administrators to adhere to curricula and prepare for standardized classes and tests also make it difficult to implement STEM. But the most serious barrier is time. To prepare a good project, it is necessary to create a professional learning community in which to build trust and work for at least a year to synchronize individual learning units. And teachers work 24/7 during the school year, so such time is difficult to allocate. Teachers also feel overwhelmed by multiple responsibilities related to school-wide initiatives and teaching, as well as continuous demands and changes in programs.

- Adapting content to students' needs.

Teachers have difficulty adapting STEM lessons to the different needs and proficiency levels of students, which requires differentiated teaching and pace adjustment. Ready-made projects can rarely be taken off the shelf. Skills for restructuring and adaptation in collaboration with teachers of other subjects.

For the difficulties listed above, which teachers share, it is good to prepare future teachers. It is necessary to familiarize themselves with and "arm" them with tools, including AI, that give them a clear idea of how to prepare for teaching in a STEM approach [1].

Mathematics education can be considered as training in mathematical modeling. It is modeling that presents mathematics in its entirety, not in frozen algorithms. It contributes to the upbringing of the basic combinatorial qualities for structured thinking. A challenge arises when, this problem must be solved, but solving it requires correctness of the task. Very often in life, we have to write the condition of the task ourselves, it is necessary to extract the information. This is the position from which we should proceed in the STEM approach. As the

mathematical model, it is necessary to adapt it to other subjects and the ultimate goal.

Responsibility for the training of future STEM teachers is essential in order to meet the growing demand for professionals in STEM skills. Future teachers of mathematics and informatics /information technologies/ are precisely those who must come out extremely well prepared, and will have a leading role in including STEM projects in the curricula. The goal is not to be good at extracurricular training courses (because this is undeniable and the implementation of STEM is mainly viewed this way), but to build such a good learning process in regular classes. Time and social needs have begun to require teachers to be much better informed and to offer innovative teaching methods, which emphasizes the need to integrate STEM training for teachers into official curricula.

A comparative analysis of the number of hours for the preparation of students in mathematics and informatics in higher education institutions in Bulgaria shows the following situation.

Table 1. Number of disciplines and hours of STEM training for future teachers of mathematics

Univesities in Bulgaria	**Couses**	**Number of hours**
SU “Kliment Ohridski”	2 EC*	cannot be determined
PU “Paisii Hilendarski”	2 specialties: - 2 EC - 3 CS**, 2 EC	 40 40 + 40
VTU “Sv. sv. Kiril i Metodii”	EC	cannot be determined
SWU “Neofit Rilski”	2 EC 1 CS	90 30
ShU “Episkop Konstantin Preslavski”	CS	50
TU Stara Zagora	1 CS	60

*Elective courses /EC/, **Compulsory subjects /CS/

The conclusion that must be made is that STEM training is extremely insufficient for future teachers and the goal set in [9] concerns an increase in the number of students admitted to STEM majors, and does not reflect the real number of hours required in STEM disciplines. There are extremely few studies in this area and they are primarily based on surveys and interviews, which does not provide a good idea of achieving a good level of knowledge of the approach by students [4, 6]. Although the analysis is limited to the fields of mathematics and computer science, it illustrates a general trend: research focuses on the impact

of STEM education on students, while aspects related to the training and qualification of teachers are minimized. The details are presented in Table 1.

To overcome these challenges, it is necessary to integrate training paths with a STEM perspective into formal education systems, since elective courses are not always mandatory, but are insufficient. Key elements of effective STEM teacher training programs include:

- Equipment and furnishing of a good base for conducting effective training;
- Well-developed methodology with which to arm students;
- Outreach training in business and public environments to build skills for identifying and developing problems to be offered to students;
- Motivational approaches for research and development pedagogical activity.

One appropriate approach is to visit not only working STEM classrooms, but also effective classes in them during pedagogical internships. A simulation of such a process with subsequent appropriate analysis by methodologists will significantly increase the preparation and give confidence to future teachers.

The concept of self-efficacy, related to the belief in one's own abilities to perform a specific task, is essential in the training of future STEM teachers. STEM training should develop skills related to the contextual environment, such as communication, research ethics, social modeling, politics and society, as well as the development of emotional and creative thinking. Programs should be based on real problems or tasks related to children's lives, and as a result of the application these skills are developed, both in students and teachers.

Training future teachers in the STEM approach is crucial for the preparation of the next generation. Research confirms that although prospective teachers still have limited knowledge of STEM, targeted training helps to increase awareness of the concept and fosters a positive attitude towards its integration. A well-planned system of STEM teaching approaches with an emphasis on mathematics will yield significantly better results in primary and secondary schools if prepared and implemented already in higher education.

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