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HOW IMPORTANT IS STEM INTEGRATION IN MODERN TEACHING: SURVEY INSIGHTS

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Abstract. STEM (Science, Technology, Engineering, and Mathematics) is one of the most significant parts of education that is broadly practiced in the school systems and has become popular over the last decade. Students are equipped with necessary skills that they need to succeed in the future job market due to the full implementation of the STEM educational curriculum. A survey was conducted among teachers, evaluating the situation with the STEM teaching in the educational system to provide valuable evidence of the importance of STEM integration as well as the challenges and opportunities of its implementation. The outcomes are indicative of strong support for STEM integration where more than 90% of those questioned have found it to be a key factor in the academic progress of students. Most of the respondents think that STEM methodologies are seriously tied to student's participation, critical thinking, and career preparation.

Keywords: STEM integration; modern teaching; survey insights

1. Introduction and Theoretical Framework

Over the years, STEM education has become a much interdisciplinary paradigm that not only emphasizes developing problem-solving, critical thinking, and creativity skills but also scientific literacy among learners. Zhou et al. (2023) characterise STEM education as a multidisciplinary approach that highlights the development of 21st-century skills such as problem-solving, critical thinking, and scientific creativity through the integration of the traditionally separate disciplines of science, technology, engineering, and mathematics. Bybee (2010) also affirms this point when he indicates that STEM's main interpretive power lies in its design-based and inquiry-driven pedagogy that aimed at helping students become capable of using innovations and technologies in real-life situations across various fields. Providing further depth, Ong et al. (2024) describe STEM education as an educational approach that systematically applies interdisciplinary concepts to solve

real-life problems, thereby creating direct links between academic disciplines and practical applications.

One of the fundamental principles of STEM approach in teaching and learning is its standing on learning-by-doing techniques such as project-based learning (PBL), inquiry-based learning, and design-based learning. Hebebci and Usta (2022) have shown that these integrated STEM methods greatly improve students' scientific creativity, problem-solving dispositions, and critical thinking skills. Particularly, inquiry-based strategies highlight the importance of developing higher cognitive levels and employing difficult tasks that are analogous to theoretical phenomena (Bybee, 2010). A study on design-based learning suggests that this method enables the students to achieve mastery in the subject by going through the process of reiterative prototyping and collaboration that parallels the current STEM teaching methods (Öndeş, 2024).

As international educational focus is moving towards multidisciplinary competences, models such as STEAM (STEM + Arts) and STREAM (Science, Technology, Reading/Arts, Engineering, Mathematics) enable STEM's technical focus to be combined with creativity and communication. The famous statement by Kamen (2013) claims that creativity – which is the "A" in STEAM – is the energy source of the innovation and the core that students need to convert technical skill into entrepreneurial insight. This integrating of arts is now the major focus of the program that aims at developing the adaptable, socially aware learners.

Admitting the quality of STEM approach in teaching and learning have led to the implementation of a number of challenges in the practice. Thibaut et al. (2018) indicate that in their search for the systematic review of these challenges, they have found continuous barriers that cover among others insufficient infrastructure, the absence of a specialized laboratory, and improper teacher training both in digital tools and interdisciplinary methods. The assessment systems based on traditional methods further worsen these problems as they are more favorable to memorization of content rather than to collaborative and creative problem-solving. Such issues are supported by Margot and Kettler (2019) who also point out that the STEM integration success is conditioned by previously mentioned reforms.

Another angle of the debate today is aligning educational goals with the so-called 21st-century skills. These skills include collaboration, digital literacy, adaptive learning, and ethical decision-making. Firstly, the National Research Council (2012) outlines these skills and sets that among them are analytical reasoning, creativity, and technological fluency. These abilities are also in direct relation to global standards that encourage the education of stakeholders to be future-oriented and deal with such issues as sustainability, equity, and digital transformation.

Several conceptual frameworks have been created in direct response to the theoretical core of STEM. To give an example, Öndeş (2024) compared inquiry-based to design-based methods in authentic engineering contexts, revealing

different aspects of student understanding. English (2023) came up with a cognitive framework that emphasizes metacognitive changes between scientific inquiry and engineering tasks. Similarly, Mishra and Koehler's TPACK model (2006) argues that good STEM instruction happens at the integration of technological, pedagogical, and content knowledge, which is adapted to the school environment and social norms.

The main aim of this study is to examine teachers' perceptions of STEM integration in modern teaching practice and to identify the main benefits and challenges related to its implementation in school education.

The study is guided by the following research questions:

How do teachers perceive the importance of STEM integration in modern teaching?

What advantages do teachers identify in the use of STEM activities in the educational process?

What challenges do teachers report when applying STEM approaches in school practice?

2. Methodology

The research adopted an empirical methodology based on a structured questionnaire disseminated among teachers in the Bulgarian educational system. The intention was to review the educators' viewpoints on STEM incorporation, its significance, advantages, difficulties, and their vision for future STEM education. The selection of a survey as a data collection method allowed for the obtaining of both quantitative and qualitative insights from a variety of teaching professionals. The survey was conducted among 52 teachers from 8 different schools located in the Blagoevgrad region, Bulgaria. The participating schools represent diverse educational contexts within the region. The selection of schools was based on accessibility and willingness to participate, rather than random sampling. Most of the surveyed teachers reported having prior experience with STEM-related activities, mainly through interdisciplinary lessons, project-based learning, or participation in school or extracurricular STEM initiatives. The duration of implementation varied from short-term classroom activities to long-term projects conducted over one or more academic years. These teachers of natural sciences, mathematics, ICT, and interdisciplinary subjects that were either actually carrying out STEM strategies or were interested in so, constituted the participants. The reported STEM activities were implemented within formal school lessons. The sample was made up both of primary and secondary school staff. Taking part in the questionnaire was optional and anonymous, thus protecting privacy and enabling truthful answers.

Research Instrument and Data Analysis

As a research instrument, a Google Forms questionnaire was used. It was custom-made to gather data on attitudes, perceptions, and experiences regarding

STEM education. The survey consisted of both closed and open-ended questions. Likert-scale and multiple-choice were the formats used for quantitative items to assess:

– the perceived importance of STEM integration;
– the impact of STEM methods on student motivation and learning;
– the applicability of STEM skills to real-life and professional contexts;
– the role of ICT in supporting STEM teaching;
– the main challenges faced during STEM implementation.

In order to get respondents' views on the future of STEM education, an open-ended question was posed, thus enabling qualitative data acquisition that supplemented the entire analysis.

The survey reached its targeted respondents electronically through various professional networks, institutional mailing lists, and teacher community forums during April and May 2025. For three weeks, the questionnaire was accessible online, and the Google Forms platform automatically gathered respondents' entries. To analyze the data, it was exported into a spreadsheet format.

The study employs a quantitative descriptive approach. Quantitative data were analyzed using descriptive statistics, including frequencies and percentages. Qualitative elements were limited to open-ended responses and were analyzed through thematic categorization. These statistics help to clarify frequency distributions, percentages, and overall trends. As a visual aid, pie and bar charts were created to depict the responses graphically. By combining the numbers' trends with the thematic content, the result is an all-embracing picture of educators' understanding of STEM incorporation. This multi-method strategy improves the trustworthiness and range of the research findings.

3. Results

This section of the paper is devoted to processing the survey data obtained from 52 teachers about the use of STEM education in modern teaching practices. The results reveal the teachers' perception of the positive influence of STEM on the educational process, the pros and cons of its implementation in their classrooms, and their thoughts for the development of the STEM field in Bulgaria. The research gets to this point by integrating numerical data with descriptive answers from educators. This methodology not only exposes present attitudes but also identifies significant barriers that are structural and instructional, which influence the infusion of STEM into the learning environment.

The first part of this discussion integrates the empirical findings with theoretical insights and literature on the subject in order to place them within the wider educational field. The analysis of each chart from the survey demonstrates regularities, tendencies, as well as variations in teachers' thinking about the issues. Subsequently, these data are explored in connection with policy, teacher training,

curriculum design, and resource allocation. This comprehensive method of synthesis expands confidence in the drawing of conclusions while allowing a more detailed grasp of the present and the prospective of STEM education at the country level. The findings confirm that teachers largely view STEM as a vital tool for modernizing education and preparing students for the demands of the 21st-century workforce. However, the data also highlight persistent challenges – technical, pedagogical, and systemic - that must be addressed to support effective and sustainable STEM integration. The results of the research indicate that educators generally perceive STEM as an essential instrument for not only updating the education system but also for enabling students with the necessary skills to meet the challenges posed by the workforce of the 21st century. The information provided focuses on the overall positive perception of STEM while also pointing that the existing problems such as technical, pedagogical, and systemic issues have to be solved in order to implement STEM integration efficiently and sustainably.

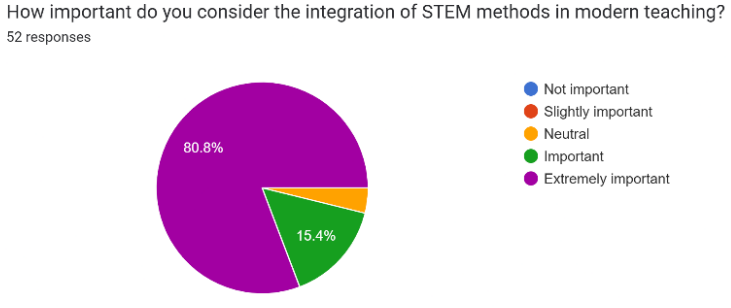

Figure 1. Perceived Importance of STEM in Modern Teaching

The first question in the survey evaluated the importance of the STEM methods integration amongst the respondents for modern education. The data shows that most teachers (80.8%) consider STEM integration to be "extremely important," while 15.4% rated it as "important." (Fig. 1). Only 3.8% of the teachers gave the statement a "neutral" or less significant. Such a broad agreement on this matter is the condition of the continuation of the statement that the educators are convinced that STEM education is the core for the development of student competencies such as critical thinking, problem-solving, and employability in the future. These findings coincide with Bybee's (2010) theoretical viewpoints, who think STEM is an essential part of rearing 21st-century skills in a tech-driven world.

Overall, the results indicate a strong positive attitude among teachers toward the integration of STEM approaches in teaching practice.

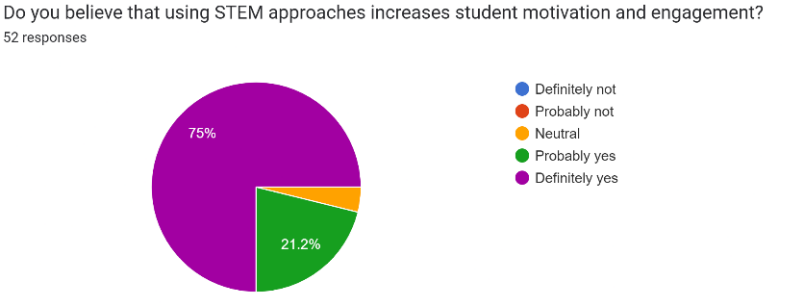

Figure 2. STEM's Impact on Student Motivation and Engagement

On being asked whether STEM methodologies improve student motivation and engagement, a massive 75% of respondents chose a "definitely yes" answer, whereas 21.2% went for "probably yes" (Fig. 2). This clearly shows that nearly all those who took part in the survey see a strong positive influence of STEM approaches on learner participation. This perception is in aligns with the results of a study conducted by Hebebci and Usta (2022), who established that active STEM methodologies, such as project-based and inquiry-based learning, bring about a significant increase in student engagement and self-efficacy. As a result, educators consider STEM not only as a curriculum enrichment, but also as a pedagogical strategy that strengthens learning environments.

The distribution of responses suggests a high level of perceived relevance of STEM education for contemporary teaching.

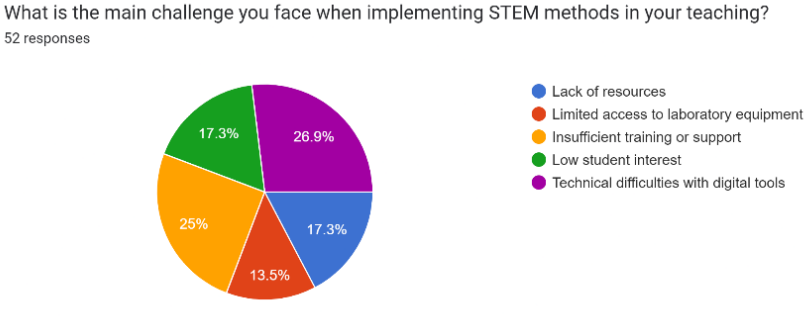

Figure 3. Key Challenges in Implementing STEM Education

However, putting STEM into practice still comes with serious barriers. Respondents revealed that the most frequent obstacle was "technical problems with digital tools" (26.9%), followed by "lack of training or insufficient support" (25%), and then "lack of resources" and "low student interest" (each at 17.3%) (Fig. 3.). Restricted access to laboratory equipment was another example that 13.5% of respondents gave. Thus, there is still the infrastructure and professional gap that affects the effective STEM provision in schools. The data also confirm Thibaut et al. (2018) findings that, however, being conceptually quite powerful, STEM's practice is challenged by systemic limitations. To narrow the implementation gap, the teachers need more than just passion – they need material resources as well as specialized training.

These findings highlight teachers' recognition of STEM as a meaningful and applicable approach within the school context.

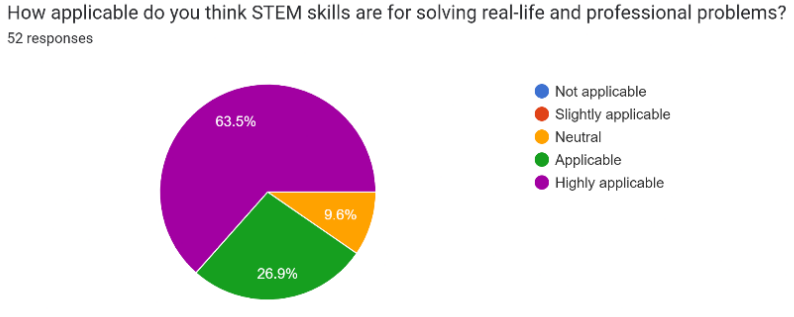

Figure 4. Applicability of STEM Skills to Real-World and Professional Contexts

According to the survey, the majority of teachers (63.5%) who participated in the poll rated STEM skills as "highly applicable" to solving real-life and professional issues, while 26.9% chose "applicable" (Fig. 4). Only 9.6% were not sure or less convinced. These answers indicate that the STEM field is generally perceived as not only academically relevant but also practically beneficial in the workforce preparation of students. The education sector's orientation towards real-world problem-solving is a major set of skills that STEM can inform, and the National Research Council (2012) puts it forth that new education has to train students with transferable skills to be able to deal with the thus changing and uncertain labor markets.

The results demonstrate that teachers associate STEM implementation with increased student engagement and active learning.

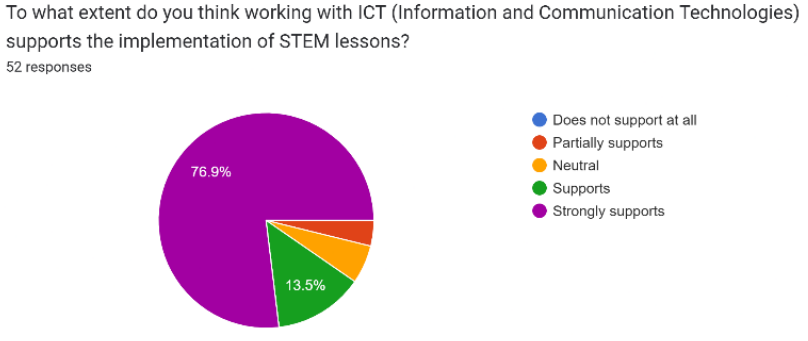

Figure 5. ICT Support in STEM Teaching

The role of ICT in aiding STEM integration was also the focus of the of the survey. A significant majority (76.9%) revealed that they felt that ICT "strongly supports" STEM teaching, and a further 13.5% indicated that it "supports" the STEM to a considerable extent (Fig. 5). Such results confirm the notion that technological devices are necessary rather than optional in the process of interfacing one subject with others in a modern educational setting. ICT is essential for simulation, modeling, data analysis, and virtual collaboration - these are the functions that STEM classrooms are focusing on. It is in line with Mishra and Koehler (2006) who argue that technology integration with content and pedagogy is the key for effective teaching practices (TPACK framework).

The responses reflect a clear tendency toward viewing STEM integration as beneficial for improving learning outcomes.

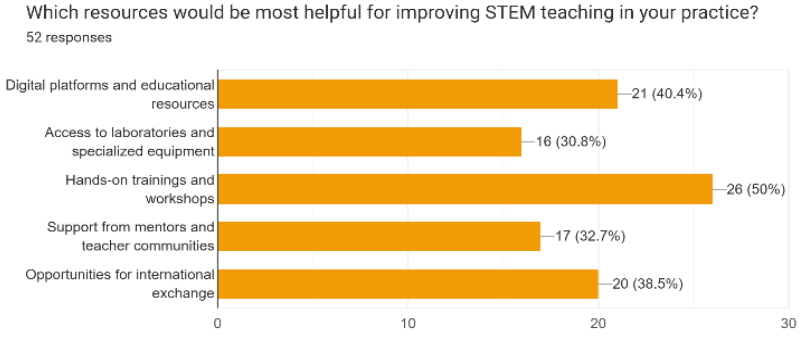

Figure 6. Preferred Resources to Improve STEM Instruction

In the survey, teachers were asked what resources they think are most effective in improving STEM teaching. Half of the people who responded said that practical training and workshops are the most valuable. After that, the voters' list of the most desirable sources of STEM teaching improvement included "digital platforms and educational resources" (40.4%), "international exchange programs" (38.5%), and "mentor support" (32.7%) (Fig. 6). These statements are suggestive of the need for more interactive models of professional development based on experience. Teachers not only recognize the pedagogical value of STEM but are also very actively engaged in locating practical tools and collaboration opportunities. The answers link with the results of Margot and Kettler (2019) that teacher empowerment via ongoing training is key to long-term success in the integration of STEM.

Overall, the data reveal a consistent pattern of positive perceptions regarding the impact of STEM-based activities.

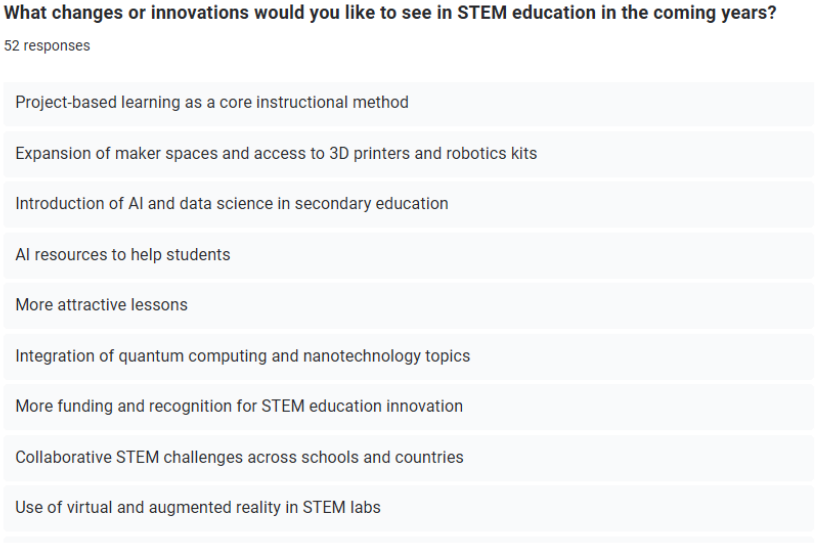

Figure 7. Future Innovations Desired in STEM Education

The concluding open-ended research question gives the opinions of the respondents about the changes that they would like to see or the innovations that would be introduced in the STEM education sector (Fig. 7). The analysis of the answers by the thematic method yielded the following main trends:

– Early introduction of coding, AI, and computational thinking;
– Greater integration of sustainability, green technologies, and climate science;
– Emphasis on project-based learning, STREAM, and interdisciplinary approaches;

– More maker spaces, 3D printers, and robotics kits in schools;
– Use of AR/VR technologies, gamification, and adaptive learning platforms;
– Development of international collaboration, mentorship, and inclusive curricula;
– Focus on soft skills, entrepreneurship, and failure-based learning models.

The summarized results further support the overall positive evaluation of STEM approaches expressed by the surveyed teachers.

4. Conclusion

The results of this research establish that Bulgarian teachers see STEM integration as vital for equipping students with the necessary skills for future academic and professional successes. They clearly confirm that educators recognize the advantages of STEM methodologies for student motivation, critical thinking, and real-world problem-solving. But at the same time, issues like insufficient resources, the lack of proper training, and technological obstacles still form barriers to the smooth implementing of STEM in education. The teachers were quite definite that they needed more practical training, the availability of digital tools, and institutional support that was stronger. Their view of the future definitely involves the inclusion of sustainable development, AI, and other interdisciplinary fields such as STREAM, which are consistent with the global educational directions. The coordinated actions in policy, infrastructure, and teacher development are required to open up the full potential of STEM education. If provided with adequate assistance, STEM has the potential to become the driving force of educational transformations in the contemporary Bulgarian teaching profession.

In response to the research questions, the study shows that teachers generally perceive STEM integration as an important element of modern teaching. They identify improved student motivation, stronger practical understanding, and interdisciplinary learning as key advantages. At the same time, limited resources, insufficient preparation, and time constraints remain the main challenges in everyday school practice.

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