ISSN 1512-1801

UDC 37.022.3.

ASSESSING STEM EDUCATION COMPREHENSION AMONG GEORGIAN TEACHERS – OBSTACLES AND WAYS OF IMPLEMENTATION

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Abstract

STEM education is widely acknowledged as a valuable pedagogical approach, furnishing individuals with indispensable skills tailored for the contemporary era. Nonetheless, its practical execution frequently encounters hurdles from diverse beliefs and attitudes toward its delineation and instructional methodologies. This study endeavors to gauge the depth of comprehension regarding the STEM educational paradigm among educators in Georgia. The study employed a quantitative research methodology. A survey was conducted among 388 teachers representing different regions of Georgia. The selection of this sample size was deliberate, focusing on a specific subgroup within the population: Teachers who exhibit a pronounced interest in STEM. These teachers had previously absorbed insights about STEM through webinars, training sessions, or workshops. The chosen sample size considers a margin of error of 5%, with a confidence level exceeding 95%, indicating substantial measurement consistency. The hypothesis posits that, given the recent introduction of STEM education in Georgian schools, teachers might misconstrue the concept and inadequately integrate it into the pedagogical process. Analysis of the research findings corroborated the validity of this hypothesis. It was observed that a significant number of teachers grappled with identifying the core criteria of STEM education cohesively, often furnishing a solitary criterion or misconstruing its fundamental essence. These findings underscore the difficulty of heightened attention and support in cultivating a lucid comprehension of the STEM approach among educators. Rectifying these misconceptions and amplifying educators' grasp of STEM concepts is important for effective integration within the educational system.

Keywords: STEM approach, Teachers' STEM beliefs, Criteria of STEM Education, Implementation of STEM.

Introduction

The term "STEM" was coined by the National Science Foundation (NSF) during the 1990s. Since then, STEM has been delineated in diverse ways (Salinger, G. & Zuga, K. , 2009). For some, STEM is defined as an amalgamation of distinct subjects, whereas others perceive it as a holistic approach to curriculum and pedagogy (Bybee, 2010). Research indicates that the latter viewpoint holds greater accuracy, as it eradicates the distinctions between the constituent disciplines of the STEM acronym. This interdisciplinary approach seamlessly fuses diverse scientific fields into a singular subject (Salinger, G. & Zuga, K. , 2009). This educational approach amalgamates intricate academic concepts with pragmatic, real-world applications. It encompasses the utilization of science, technology, engineering, and mathematics in scenarios that bridge the realms of academia, community, industry, and the global market. By cultivating STEM literacy, this method empowers

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students with the proficiencies requisite for thriving in the contemporary economy (Tsupros, N., Kohler, R., & Hallinen, J., 2009). STEM education is recognized for possessing the subsequent advantages over conventional science education: Fostering Innovation: Through the amalgamation of subject domains, STEM education stimulates innovation. This integration aids students in forging fresh connections between disciplines (COC, 2005). It bridges the four fields of the science, technology, engineering, and mathematics classroom. This approach diverts students from memorizing isolated fragments and procedural routines, directing their focus toward exploring and scrutinizing the interconnected aspects of the world (NGA, 2008). 2. Inherent Engagement with Complex Problems: STEM education intrinsically entails grappling with ill-structured problems that hold direct ties to the tangible world. Thorough research has been dedicated to scrutinizing the essence of these challenges and their impact on educational results. The outcomes of these investigations reveal that as the intricacy of the problems escalates, students amass a broader spectrum of skills. (Capraro, M. R., & Slough, W. S., 2013; Russell SH, et al., 2007; D., 2004). STEM education underscores the profundity of knowledge by engaging in activities such as adeptly communicating original concepts within the domain of existing knowledge, forging links between knowledge and real-world scenarios, amalgamating knowledge to address challenges, and contemplating the strengths and limitations inherent in the solutions. (Capraro, M. R., & Slough, W. S., 2013); 3. Models and the practice of modeling assume a pivotal role in the domains of problem-solving, predictions, and effectively communicating concepts and constructs (Hallström, J. & Schönborn, K., 2023). Scholars like (Müller, 2019) and (Vincenti, 1990) have emphasized their significance. Models serve the purpose of elucidating diverse facets of reality, spanning from straightforward conceptual diagrams and early prototypes to sophisticated mathematical models and even machine learning algorithms. Consequently, competencies associated with creating, utilizing, applying, evaluating, and revising models become indispensable for attaining a holistic grasp of scientific practices, technological and engineering design, and mathematical instruments, as emphasized by Schwarz (Schwarz, C. V. et al., 2009). 4. To enhance clarity, the "T" in STEM signifies a discipline with the educational objective of cultivating technological literacy for all (Wells, 2019). 5. One of the earliest research inquiries into project-based learning revealed that projects elevate student engagement in STEM subjects. This increased interest is attributed to the inclusion of projects that engage students in tackling authentic real-life issues, collaborative teamwork with peers, and the creation of tangible outcomes or artifacts. (Fortus, D., et. al, 2005). Subsequently, (Berk, L. J et al., , 2014) discovered that students who students exposed to project-based learning showed more positive attitudes toward STEM disciplines and displayed an increased inclination to pursue careers in STEM fields. A recent study (LaForce, M. Noble, E., & Blackwell, C., 2017) investigated the relationship between inclusive STEM high school students' perceptions of PBL and their interest in STEM subjects and careers. Their findings highlighted a correlation between students' higher evaluations of PBL and a heightened interest in STEM subjects and careers. (Alpaslan, 2019). 6. It fosters real-life learning opportunities for students by cultivating a learning environment in which students not only learn 21^{st}-century skills but also have the opportunity to develop new skills (Bybee, 2010; Narum, 2008). Educators striving to equip students with collaborative workplace skills often employ a STEM project-based learning model that offers opportunities for group problem-solving. (Shofiyah, N. et al,, 2022).

STEM education is central to motivating and arming students with the fundamental skills and knowledge for embarking on STEM careers. For instance, the integration of STEM education in the United States yielded a remarkable 43% surge in undergraduate enrollment within STEM programs from 2010 to 2016, as documented by Emsi, an economic data modeling organization (Jones, 2020). These notable figures underscore the efficacy of STEM education in enticing students towards STEM fields and readying them for forthcoming career trajectories. A significant impediment encountered by STEM education in developing countries is the widespread misconception among educators that it merely constitutes a revamped version of conventional science and mathematics teaching (Bybee, 2010; Kaufman, et. al, 2003). Furthermore, these educators seem to lack the

ISSN 1512-1801

understanding that STEM education extends beyond merely including technology and engineering elements within traditional science and math courses. Hence, a scarcity exists of meticulously designed and proficiently implemented STEM curricula within educational institutions. (Lantz, 2009). The effectiveness of introducing STEM education hinges on the unique learning context; however, it seems that in most implementation strategies for STEM education within developing nations, there is a greater emphasis on the "Science" and "Mathematics" components rather than adequately addressing the broader "Science, Technology, Engineering, and Mathematics" components. Within the current paradigm of STEM education, engineering, and technology have not been accorded the same degree of attention as science and mathematics (Hayes, 2017). Many countries in the world are confronted by several issues in STEM education (Sturman, L., et. al, 2012). These challenges are especially severe in underdeveloped nations. A few of these difficulties comprise (Kalolo, 2016): Firstly, in developing nations, science courses have largely failed to motivate students to pursue STEM education and related professions in the future. Consequently, students do not connect with STEM subjects or perceive them as aligning with their self-identity and ambitions. A substantial number of young individuals display limited enthusiasm for embracing STEM professions, a sentiment rooted in adverse encounters with STEM subjects during their schooling. These students frequently deem STEM courses as arduous and uninspiring,, leading to disengagement from the field (Wilson, 2011); In addition, numerous nations grapple with a pressing concern of inadequate backing and training for educators, particularly in keeping abreast with evolving scientific theories, industry trends, and progressions. Teachers frequently find themselves unfamiliar with contemporary developments and instructional approaches within STEM domains. Moreover, educators at lower educational levels might experience discomfort when tasked with instructing STEM subjects, as these areas may not align with their specialized expertise; Moreover, the methods employed for identifying and nurturing STEM talent in the majority of education systems within underdeveloped nations are inadequate (Tsupros, N., Kohler, R., & Hallinen, J., 2009). Consequently, a substantial number of students, especially those harboring innate aptitude and fervor for STEM, are deprived of formal education in these fields, leading to restricted opportunities to develop their abilities. Recognizing and assisting students showcasing latent talent and enthusiasm for STEM from an early juncture is important in propelling them to realize their career aspirations in STEM fields; Equally important, there is growing concern regarding the decreasing number of college students obtaining degrees in STEM subjects, coupled with the insufficiency of the workforce being adequately equipped for vocations within science, technology, engineering, and math (IHE, 2007). This situation contradicts the increasing demand for positions within STEM sectors. As a result, there is a decline in economic and security power due to the lack of scientific knowledge and the inability to produce a workforce educated in STEM. This workforce is essential for developing new and innovative technologies, expanding and creating new markets, and generating more employment opportunities; Additionally, the effectiveness of implementing STEM education is determined by several beliefs that are considered crucial viewpoints. These beliefs can be categorized into three principal domains of consideration: support structures, teacher recruitment, professional development, and assessment practices (Noha, 2013; PCAST, 2010); Although STEM education has many benefits, student outcomes alone do not provide a complete picture of learning achievement. For instance, gauging a student's interest, motivation, and creativity in STEM education based solely on their academic performance is challenging. Hence, supplementary evaluation approaches are imperative to gauge the accomplishment of STEM education. This might encompass appraising a student's capacity to showcase skills acquired during instruction and scrutinizing their involvement in extracurricular activities; Enhancing STEM education within schools involves considering the quality of instruction as a significant criterion for evaluating its successful implementation. Research has demonstrated that effective STEM education requires instructional methods capable of arousing students' interest and immersing them in authentic STEM practices (Wilson S. M., 2011); In conclusion, effective STEM instruction requires several critical factors, including supportive school conditions, a reliable assessment and accountability system, a coherent set of standards and

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curriculum, highly skilled teachers, adequate instruction time, and equitable access to high-quality STEM learning opportunities (NRC, 2007).

Strategies to Ensure Effective Implementation of STEM Education

To optimize the advantages of STEM education, employing efficient strategies that ensure its proper implementation is paramount. Methods to secure the successful enactment of STEM Education include: Multiple research studies have underscored a spectrum of potential interventions that could contribute to the triumphant implementation of effective STEM education (Narum, 2008; PCAST, 2010). These interventions can be classified into three main groups: practice-level interventions (such as school-based interventions), policy-level interventions (such as policy-focused interventions), and partnership-based interventions; A matter of concern is the reduction of instructional time dedicated to science education, as research indicates that sufficient instructional time plays a pivotal role in fostering interest in science careers (Wilson S. M., 2011). It is crucial to allocate sufficient resources and instructional time to STEM education in the early grades of schooling. This is not only essential but necessary for establishing a solid foundation that can stimulate students' interest in taking additional science courses in middle and high school and potentially pursuing STEM disciplines and careers; According to research studies, providing academic support structures for students has notably influenced students' engagement and interest in STEM studies (NRC, 2007). To effectively implement STEM education, teachers need to establish a supportive learning environment that promotes student engagement and interest in the subject. This can be attained through personalized teaching, mentoring, participation in STEM club activities, counseling, and guidance. The classroom culture should foster critical thinking and prompt students to take responsibility for their learning journey, transcending the passive reception of information. Teachers should steer students toward independent or collaborative learning with their peers; An effective STEM education can be evaluated by the consistency of its curriculum and standards. STEM education can be considered successful when the curriculum is focused on essential topics in each subject and arranged in a progression of topics and skills. Studies show that implementing rigorous standards coupled with the harmonization of curriculum and assessments to those standards, can result in enhanced academic performance among students. (Morrison, J & Bartlett, R, 2009); To deliver successful STEM education, teachers must possess expertise and knowledge in STEM subjects (Gamoran, A., Anderson, C. W., et al., 2003). Regrettably, a significant number of science and mathematics educators appear unready to meet the requisites of effective STEM education. The professional development initiatives accessible to STEM teachers have frequently been deficient, lacking structure, and ineffectual. Moreover, these programs often fail to address individual teachers' distinct requirements. (Wilson, 2011). To ensure success in STEM education, it is necessary to restructure teacher development programs to provide a continuous improvement process that starts from initial preparation and extends through induction into teaching practice. Redefining teacher education programs involves focusing on three key aspects: enhancing teachers' mastery of subject matter and pedagogical techniques, addressing the challenges they encounter in their classrooms, and offering sustained and diverse opportunities for ongoing teacher learning over an extended period.; For the accomplishment of STEM education, the establishment of a thorough and efficacious assessment process is imperative, encompassing both formative and summative feedback. This will facilitate schools in evaluating whether their curriculum is yielding the anticipated results on student achievements. Such an assessment system offers numerous advantages, including creating a shared vision and objectives for science education across all stakeholders, monitoring students' progress in science over time, and concentrating on teacher practices and student accomplishments. However, numerous current assessment practices might inhibit educators from utilizing effective methods to foster high-quality STEM education (Kalolo, 2016); Several factors lead to disparities in providing equitable STEM education to all students (OECD, 2006; Robelen, 2011). Several factors contribute to disparities in STEM education at the classroom level. These factors include uneven access to proper laboratory facilities, resources,

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and supplies, as well as differences in the availability of well-trained and certified teachers, less challenging STEM classes, and inadequate methods for identifying STEM talents in early grades. These disparities lead to underrepresented groups attaining inferior outcomes.. Therefore, policies are necessary to guarantee well-trained teachers are available to address the imbalance in access to quality STEM education and associated school services; To enhance the state of STEM education, it is necessary to enact policies that elevate the status of overlooked domains, such as technology and engineering education to the same significance level as mathematics and science. Furthermore, establishing effective evaluation mechanisms is crucial (IHE, 2007; Kuenzi, 2008). There is currently a lack of policy interventions in STEM education within schools (Salinger, G. & Zuga, K. , 2009). The present circumstances necessitate states and national organizations to create efficient assessment systems that conform to the next generation of science standards and prioritize applying scientific practices instead of solely focusing on the recollection of facts; Increased involvement from all stakeholders, including schools (administrators, teachers, laboratory assistants, and career counselors), universities (faculties of education and science), education ministries (policymakers, curriculum developers, inspectorates, and local education authorities), associations (teacher and science organizations), STEM companies, publishers, media outlets (science journalists, TV, and internet programs), science centers and museums (school outreach staff and science communicators), youth associations, community groups, and government entities (local authorities, ministries of science, technology, and research) is necessary. When these stakeholders are engaged efficiently, they can assist STEM education by establishing partnerships with schools through various means, such as funding and advisory assistance (P21, 2011). The objective of engaging multiple stakeholders is to establish a shared responsibility for enhancing STEM education. It is important to integrate all aspects of STEM implementation, spanning from formal to informal education , and encompassing from student to policy maker. This integration empowers the private sector to contribute toward tackling the STEM education challenge without being reliant on permissions from state governments; Collaborations between schools and external organizations significantly the effective execution of STEM strategies (Bybee, 2010; Skills, 2011). This intervention increases the ability to provide high-quality STEM education and learning opportunities. The success of any STEM education initiative is not solely determined by individual school efforts, encompassing elements such as professional development, curriculum, or afterschool programs, but by the alignment of interests between the school and the community; Countries that have successfully implemented STEM education programs have utilized various strategies to ensure their success. In countries like Finland, there is a strong emphasis on providing teachers with high-quality training and professional development opportunities (Sahlberg, 2015). This policy ensures that teachers have the knowledge and skills to effectively teach STEM subjects. In Singapore, a robust collaboration exists between universities and industries, ensuring that STEM education programs remain aligned with industry requirements (Tan, 2018). This ensures that students are prepared for the job market. Countries such as South Korea and Japan commence introducing students to STEM subjects from an early stage. This early exposure aids in establishing a solid foundation and fostering enthusiasm for STEM subjects. (Lee, 2017). Integrating technology in STEM education is another comprehensive policy approach utilized by different successful systems. Many countries, including the United States, have incorporated technology into their STEM education programs. This encompasses utilizing online resources, virtual laboratories, and other technological tools to enrich the learning process (Honey, 2014). Many countries also explored supportive policy environments. These nations have formulated policies that advocate for STEM education, including the provision of funding and resources for STEM programs and initiatives. Countries have successfully implemented STEM education programs through these strategies, ensuring their students are equipped to confront future challenges.

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Research design

Research Objective

The study's objective is to evaluate the extent of understanding of the STEM (Science, Technology, Engineering, Mathematics) educational approach among educators in Georgia, pinpoint any comprehension gaps, and proactively seek remedies to rectify them. The study aims to identify gaps in their comprehension and subsequently seek solutions to address them. Given the recent introduction of STEM education in Georgian schools, there is a high probability that teachers might misconstrue the definition of the STEM approach and misapply it within the educational framework.

Research Methodology

The study was conducted within the timeframe spanning from December 16, 2022, to March 29, 2023, with teachers serving as the sampling unit. A survey was distributed via email to 4,800 teachers who had participated in STEM content activities organized by the Science Teaching Support Program operated at the National Center for Teacher Professional Development. These teachers had previously gained exposure to STEM concepts through webinars, training sessions, or workshops. All selected teachers were allowed to complete the questionnaire. Participation was voluntary, and teachers were required to provide informed consent. In total, 388 teachers actively engaged in the research study. This sample size was determined by the specific population subgroup, facilitating a margin of error of 5%. The confidence level surpasses 95%, underscoring the heightened reliability of the measurements.

Participants

The survey garnered active participation from 388 teachers representing all ten regions of Georgia. Among these teachers, 94.1% were female and 5.9% were male. Their primary teaching fields encompassed a spectrum of traditional disciplines. Specifically, 71.4% were specialized in subjects such as Physics, Chemistry, Biology, Mathematics, and Geography. Furthermore, 9% were primary school teachers responsible for concurrently instructing Natural Sciences, Mathematics, Georgian language, and literature. The remaining 19.6% were dedicated to other subjects. The survey participants had varying years of teaching experience, spanning a range of 1 to 48 years. Within this group, 23.2% had less than ten years of teaching experience, while 76.8% had more than ten years of experience. Among the respondents, senior teachers constituted 50%, followed by leading teachers at 37.6%. Mentors accounted for 7.7% of the participants, while non-certified teachers represented 4.7%. The age distribution of the teachers was categorized based on the major political eras of Georgia. The breakdown is as follows: those aged less than 30 years old accounted for 7.7%. Individuals between the ages of 31 and 40 comprised 21.6%, those falling within the 41-54 age bracket represented 43.3%, and those aged 55 and above constituted 27.3%.

Instrument

The research methodology utilized in this study involved a structured quantitative research questionnaire that amalgamated a blend of open-ended and closed-ended questions. Certain statements within the questionnaire were assessed using a Likert scale. The questionnaire was administered through the "Google Form" platform, with participating teachers being furnished with the research tool's email address for convenient access. A pilot study encompassing 20 teachers was undertaken before commencing the primary data collection. The aim of this pilot study was to assess the clarity and comprehensibility of the questionnaire. Drawing from the feedback garnered during the pilot study, minor revisions were incorporated to refine the clarity of certain specific questions. To establish the questionnaire's reliability, the Krombach method was employed, yielding

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an indicator value of 0.648. This value indicates that the questionnaire possesses sufficient validity. The initial section of the questionnaire encompassed questions related to basic demographic characteristics, while the subsequent section comprised statements aimed at assessing knowledge levels.

Limitations of this study

Considering the meticulous selection of the population, the rigorous sampling technique, the optimal number of respondents, and the high quality of completed questionnaires, the study was conducted without any notable limitations that could undermine the validity and integrity of the research findings.

Data analysis Techniques

The data obtained from the research study were analyzed using the statistical software SPSS. A recoding method was employed to handle the open-ended questions, which involved grouping similar types of questions in a specific sequence. For instance, the question regarding teachers' understanding of STEM education was coded based on five predetermined criteria. In alignment with pertinent literature and the author's viewpoint, a comprehensive STEM teaching approach is discernible when a constellation of crucial criteria is concurrently fulfilled. These criteria encompass:

- Implementing problem-based learning that emphasizes the practical application of knowledge.
- Establishing connections between various STEM disciplines to foster interdisciplinary understanding.
- Encouraging project work, research, and experimentation to promote hands-on learning experiences.
- Empowering students to create engineering models using digital technologies and Implementing digital learning resources during the teaching process.
- Facilitating group work and ensuring the inclusion of all students in the learning process.

Each listed criterion was assigned equal significance, thereby contributing to the establishment of a measure of STEM understanding. A comprehensive understanding of STEM was defined as the ability and knowledge of all five criteria, indicating a thorough knowledge of the subject. Individuals who referenced only one criterion were regarded as having a restricted understanding of STEM, implying familiarity with the acronym or relying solely on one of the enumerated criteria for elucidation.

Similarly, the question "Please provide an example of the most recent problem-based learning experience you have had" underwent analysis using the identical methodology. The responses were categorized as follows: absence of an answer, unidentified response, misunderstanding, and correct understanding. Based on the existing literature, conclusions about Problem-based learning (PBL) proficiency were made. Problem-based learning (PBL) emerges as an active pedagogical strategy that empowers students to proactively partake in problem-solving, explore data, propose solutions (Souza, N.R. & Verdinelli, M.A., 2014), and deliberate upon their experiences (Barrows, H.S., & Tamblyn, R., 1980).. By situating learning in real-world problems, PBL fosters active learning and cultivates student responsibility for their educational journey (Cindy, 2004). During Problem-Based Learning (PBL) problem posing can be approached through various methods, such as broad problem posing, inquiry-based problem solving, divergent thinking problems, product development, real-life problem solving, role-playing scenarios, solving real-life mathematical problems, multidisciplinary problem solving, authentic learning scenarios, utilizing escape rooms, solving

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hypothetical problems, addressing social problems, solving riddles, engaging in situated learning, transforming exams into challenges, creating applications, developing plans for environmental regeneration, and tackling social issues (Cornell, 2023).

Data analysis

The prevalent references in the respondents' answers concerning the definition of STEM were as follows: integration of subjects (28.6%), project/experiment/learning by doing (19.6%), problem-based learning (17.0%), engineering-technology (10.6%), and teamwork (0.5%). Based on the assessment of the STEM educational approach, the distribution of understanding was as follows:

Table 1 The distribution of understanding STEM education among participants

Responses	%
According to the author, a teacher does not know or does not have the answer to what STEM is	43.8
Explains an abbreviation or names only 1 criterion	38.4
Names 2 criteria	15.7
Names 3 criteria	1.8
Names 4 criteria	0.3
Names 5 criteria	0

Given that naming only one criterion cannot be considered sufficient knowledge of STEM, it is notable that only one person mentioned four criteria. This suggests that teachers do not comprehensively understand the subject regardless of their experience and self-assessed knowledge of STEM. Of the surveyed teachers, 84.8% claimed to know about STEM; however, only 19.4% of them could identify two to three criteria associated with STEM. The study found no direct correlation between age groups, teachers' experience, and their level of STEM knowledge. This absence of correlation is likely attributed to the recent introduction of STEM education in Georgia, which is equally novel for both experienced and younger teachers. The participants' ages were classified according to significant political eras: until 1990, 1990-2002, 2003-2012, and 2013-present. Although an average teaching experience of 20 years was taken into consideration to shape a teaching perspective, no substantial connection was identified between this age distribution and the comprehension of STEM. The findings unveiled that in the Adjara and Samegrelo-Zemo Svaneti regions, an equivalent 25% exhibited familiarity with 2-3 criteria, whereas in the capital, this proportion was 17.9%. In large regions such as Imereti, it emerged that 12.5% were conversant with only 2-3 criteria. The awareness of STEM among participants was logically distributed based on subjects. Specifically, The recognition of 2-3 criteria within physics, chemistry, biology, geography, and mathematics subjects amounted to 19.5%. Elementary grade teachers displayed an awareness rate of 17.2%, while other subjects registered at 10.5%. Consequently, it can be inferred that teachers specializing in Physics, Chemistry, Biology, Geography, and Mathematics, as well as elementary educators, exhibit a heightened level of STEM knowledge in comparison to teachers within other disciplines. Reflecting upon this evaluation of PBL, the understanding of it was distributed as follows:

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Table 2 The distribution of understanding PBL among participants

Responses	%
Does not have the answer	37.6
Unidentified response	9.3
Misunderstands	21.1
Understands correctly	32.0

A substantial portion of the respondents (81.1%) claimed to utilize problem-based learning (PBL), although only 32% could confidently state that they understood and implemented it correctly. The remaining respondents either refrained from providing a response, exhibited uncertainty, or delivered responses that lacked clarity. Moreover, 17% of the participants considered PBL to be a component of STEM. Interestingly, 19.7% of the interviewees acknowledged that learning by doing experiments and projects forms integral facets of STEM within the pedagogical process. However, it is noteworthy that 87.5% of teachers claimed to employ learning by doing experiments in their teaching practices, indicating that they are unaware that these elements constitute key criteria of STEM.

A small percentage of respondents (10.6%) mentioned including technologies in their definition of STEM. However, it is noteworthy that most teachers (75.5%) stated that they incorporate digital electronics elements in their teaching process. This suggests that teachers may not be aware that the use of is one of the fundamental criteria of STEM. Furthermore, when asked about their understanding of STEM teaching, the teachers did not mention the term " interdisciplinarity "s. Instead, 28.6% of teachers considered integrating subjects to be STEM's defining characteristic. This indicates that the majority of teachers perceive STEM as an integration of subjects rather than an interdisciplinary approach. Among the survey participants, 38.9% indicated the existence of a STEM club within their respective schools. Within this subgroup, 21.9% affirmed their familiarity with more than one criterion pertaining to STEM. In contrast, a mere 15.3% of respondents without a club displayed an acquaintance with more than one criterion. Teachers gauged the degree of collaboration among their peers within the school during the implementation of the STEM approach, employing a Likert scale comprising five response options. This scale spanned from 1 (representing "very bad") to 5 (representing "very good"). The distribution of evaluations was as follows:

Table 3 The level of collaboration among teachers while implementing the STEM approach

Rate	%
Very bad	5.7
Bad	10.8
Neutral	35.6
Good	30.4
Very Good	17.5

95.9% of the surveyed teachers have decided to stay in teaching.

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Conclusion and Recommendations

The study examined the level of comprehension of STEM (Science, Technology, Engineering, Mathematics) educational approach among Georgian teachers to recognize gaps in comprehension and actively seek solutions to address them. The study endeavors to identify gaps in their understanding and pursue solutions to address them. The hypothesis was that due to the recent introduction of STEM education in Georgian schools, there exists a substantial likelihood that teachers might misconstrue the definition of the STEM approach and, consequently, misapply it within the educational process. The examination of the research findings demonstrated the validity of the proposed hypothesis. This assertion gains support from the notable observation that a considerable proportion of teachers exhibited difficulty in collectively identifying the fundamental criteria for STEM education. Their responses often either included just one criterion or demonstrated a complete misunderstanding of its essence. This observation is further underscored by the recognition that, given the nascent status of STEM education in Georgia, the clarity of understanding did not exhibit a correlation with teachers' years of experience or age. Once more, the research has reaffirmed the concept that subject integration is the predominant association with STEM among educators. The findings unveiled that teachers held rudimentary elements of STEM pedagogy in their experiences; however, their responses highlighted a deficiency in establishing a connection between these elements and the overarching concept of STEM. Consequently, it is recommended that attention be given to establishing STEM as a cohesive instructional approach. The research findings indicated that a majority of participating teachers incorporate hands-on learning and experimentation within their instructional methods. Furthermore, it is noteworthy that only a small subset of respondents exclusively defined STEM as robotics or engineering and technology. This suggests that steering the trajectory of STEM education in the right direction is relatively attainable. Interestingly, a slight variation emerged between the number of teachers who identified multiple criteria and had a STEM school club compared to those who recognized multiple criteria but lacked a STEM club. This suggests that the presence of a club within the school doesn't significantly impact the level of understanding of STEM in this context. Therefore, it is recommended that an evaluation of the club's efficacy and the teachers' involvement with it be reviewed. Furthermore, the popularity of STEM exhibited uneven distribution across different regions, prompting the need to investigate the factors contributing to this disparity. It is intriguing to explore the factors that led to an increase in STEM awareness in regions where relatively higher levels were observed.

It was determined that problem-based learning (PBL) encounters similar challenges as STEM when examined independently. For instance, in the case of PBL, teachers often claim to use it, but the study revealed that they possess a flawed understanding of its core principles. This was evident from the analysis of the examples of PBL provided by the teachers.

Almost half of the interviewed teachers evaluate cooperation positively. Collaboration among educators holds crucial significance within the framework of STEM education due to its inherently interdisciplinary nature. Through cooperative efforts, teachers can craft captivating learning environments, cultivate linkages across various subject domains, and facilitate the cultivation of critical thinking and problem-solving abilities in students. Furthermore, collaborative efforts enhance the professional growth of teachers and help create a supportive community of educators dedicated to delivering high-quality STEM education.

Considering that a majority of the interviewed teachers exhibit motivation and a commitment to their teaching careers, coupled with a keen interest in the STEM approach and a degree of familiarity with its correlated instructional methodologies, it is plausible to deduce that they harbor the potential to integrate the STEM approach into their classroom practices adeptly. However, to ensure the successful integration of STEM education within mainstream educational institutions, it is imperative for government bodies, academic institutions, and industry associations to

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collaboratively develop a comprehensive strategy. This strategy should focus on advancing STEM education by highlighting its advantages and scope and disseminating the accurate definition of STEM throughout the educational community.

Acknowledgments

We would like to express our sincere gratitude to National Center for Teacher Professional Development for providing the email contacts of teachers for our research.

Funding

This project was funded by Volkswagen Foundation grant Az. 93 562.

Competing interests

The authors have affirmed the absence of any potential conflicts of interest regarding the study, authorship, and/or publication of this article.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request. Interested parties can contact the corresponding author via email at mediabramishvili@gmail.com.

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Article received 2023-10-21