Research on Attitudes toward the Implementation of the STEM Approach in General Education Schools of Georgia

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Abstract

The article presents the methodology and results of the research conducted by Iakob Gogebashvili Telavi State University within the framework of the grant project "STEM Concept for the Development of Teacher Preparation Educational University Programs", funded under the project "Innovation, Inclusion and Quality Project – Georgia I2Q (WB)". The target group consists of the principals of pilot schools selected within the project, as well as teachers of natural sciences, mathematics, and technology, and students of the combined bachelor's and master's program of primary education teacher preparation. Within the framework of the research, the readiness of the pilot schools to implement the STEM approach was examined from human, methodological, and material perspectives. As part of this process, qualitative research (focus group interviews) was conducted with in-service and pre-service teachers, as well as with school principals. After processing the interviews, the data were analysed according to the following codes: knowledge and experience; cognitive and emotional reactions; intrinsic motivation; openness to new experiences; material resources; administrative support; social and cultural influence; and expectations for professional development. The research confirmed the researchers' assumption regarding the need to implement the STEM approach in schools as a foundation for strengthening interest in the natural sciences. As a result of the research, it was found that, despite the scarcity of knowledge and experience, the attitude toward STEM education in schools is clearly positive. Schools recognise the importance of STEM education as a necessary condition for introducing an innovative teaching format in the modern educational environment. The research results revealed that the participants possess high motivation and readiness to implement STEM approaches in practice; however, several factors hinder this process: insufficient material and technical resources, a shortage of instructional materials, a lack of methodological and administrative support, and limited experience. Despite this, a clear openness to innovation is evident, along with a desire for collaboration with the university and for raising awareness regarding the integration of STEM education into formal education. The readiness of school principals, in-service teachers, and pre-service teachers to implement STEM represents a positive trend that requires systemic support at both the state and institutional levels.

Keywords: Project STEM-UPD; Teacher Professional Development; STEM Approach in Formal Education; School; pre-service teachers

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1. Introduction

STEM education is widely practised in many countries around the world. Its goal is to prepare students for life in a modern technological society and to develop their critical thinking, problem-solving, project management, and implementation skills. The aim is to educate individuals who are capable of functioning and adapting effectively in today's high-tech world.

The abbreviation **STEM** is used as the name of an approach that describes the integration of **Science, Technology, Engineering,** and **Mathematics** into educational curricula. STEM education encompasses the following four components:

1. S – Science: Natural Sciences
2. T – Technology: Technology
3. E – Engineering: Engineering
4. M – Mathematics: Mathematics

There are numerous definitions of STEM education. According to Sanders (2009), it is defined as "teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects." Moore et al. (2014) defined integrated STEM education as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (p. 38). According to Vasquez, Sneider, and Comer (2013), "STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering, and mathematics and integrates them into real-world, rigorous, and relevant learning experiences for students" (p. 4).

Despite differing opinions on how many disciplines should be integrated, it is clear that STEM education implies establishing connections between subjects and applying knowledge and skills simultaneously in everyday life.

The main principles of STEM education include:

- Integration – combining knowledge and methods from multiple disciplines;
- Relevance to real life – connecting learning to everyday experiences;
- Promotion of the 21st century skills – fostering critical thinking, creativity, collaboration, and communication;
- Student engagement through practical challenges – encouraging active participation in hands-on, problem-based tasks;
- Freedom of expression and problem-solving – allowing students to explore ideas and find multiple pathways to solutions.

2. Literature review

STEM education is a relatively recent phenomenon in global educational policy. At the beginning of the 20th century, following the Industrial Revolution, there emerged a growing demand for a workforce equipped with technical and scientific skills. This demand led to the development of educational directions that focused more intensively on science, technology, engineering, and mathematics (Meu Labs, 2024).

It should be noted that one of the first countries to officially recognize STEM education and its importance was the United States of America. With the adoption of the National Defense Education Act (NDEA) in 1958, the U.S. allocated significant funding for

the development of STEM education. This is considered the beginning of a major effort to improve STEM education in the United States (Meu Labs, 2024).

In 2001, American biologist Judith A. Ramaley coined the acronym STEM. She defined STEM as an educational approach in which learning is organised contextually, and students address real-world problems through the process of creating opportunities and striving for innovation (Chute, 2009).

Over time, STEM education gained popularity as an interdisciplinary approach that integrates four subjects into a single, cohesive curriculum rather than treating them as separate fields. It emerged as a response to the demands of the modern workforce and the challenges of industrial progress. The STEM approach further evolved with the introduction of 21st-century skill requirements, emphasising not only traditional technical competencies but also creative thinking, critical thinking, communication, and collaboration skills. This broader perspective led to the transformation of the acronym STEM into STEAM, through the inclusion of the arts alongside the original four disciplines (Meu Labs, 2024).

Thus, it can be said that STEM education began in the United States in the 1950s, but its active development and recognition as a priority field took place in the early 21st century. Today, the STEM approach is a priority in many countries. Naturally, the success and global popularity of STEM education have also influenced Georgia, where the implementation of STEM principles in the educational system has become increasingly active.

3. Methodology

The research was carried out within the framework of the Innovation, Inclusion and Quality Project – Georgia (I2Q, WB), under the grant-funded project "STEM Concept for the Development of Teacher Education University Programs." The project was implemented by Iakob Gogebashvili Telavi State University (Georgia) in collaboration with Akaki Tsereteli State University (Georgia). The project partners were Ltd STEAMit (Georgia) and the Copernicus Science Centre (Poland). Within the project, pilot schools were selected, and the study involved teachers of natural sciences, mathematics, and technology employed in these schools.

3.1. Methods

At the initial stage, the readiness of the pilot schools for the implementation of the STEM approach was examined from human, methodological, and material perspectives. Within this framework, both quantitative and qualitative research were conducted involving in-service and pre-service teachers as well as school principals.

Qualitative research: a focus group interview was conducted with principals of the schools involved in the project, who were selected randomly. The research instrument was an online interview conducted via the Teams platform. The interviewees discussed five open-ended questions related to the principals' attitudes and awareness regarding STEM education, as well as the role of the principal as an educational leader in strengthening STEM-based teaching within the school.

Focus group interview with pre-service Teachers involved in the project: One focus group interview was conducted with 12 students from Akaki Tsereteli State University (ATSU), selected randomly, and another focus group interview was conducted with 10 randomly selected students from Telavi State University (TESAU). The research instrument was an online interview conducted via the Teams platform, which focused on the participants' attitudes and awareness regarding STEM education.

Focus group interview with teachers from schools involved in the project: Within the framework of the project, 22 focus group interviews were conducted with STEM subject teachers selected from the participating schools. Of these, 12 interviews were held with teachers from the Kakheti region and 10 with teachers from the Imereti region. The qualitative research was carried out online using the Teams platform. The target group consisted of teachers of natural sciences, mathematics, and computer

technologies from public and private schools in the Kakheti and Imereti regions. The teachers discussed a set of specially designed questions that focused on their attitudes and awareness regarding STEM education, as well as the difficulties and challenges they face in implementing it within the teaching and learning process.

The qualitative research on pre-service teachers includes an analysis of students' opinions based on a set of pre-developed questions. The target group consisted of students involved in the project from the teacher training programs of Iakob Gogebashvili Telavi State University and Akaki Tsereteli State University, with a total of nine participants. The research was conducted in the format of an online meeting (interview) via the Teams platform. The research instrument was a questionnaire containing open-ended questions designed to prompt discussion among the students.

3.2. Participants

The participants of the study were principals (10 principals — 5 from schools in the Kakheti region and 5 from schools in the Imereti region) and teachers of pilot schools (91 teachers participated in the interviews), students of the teacher training programs (9 participants) at Iakob Gogebashvili Telavi State University and Akaki Tsereteli State University.

3.3. Procedure

The following research question was formulated to obtain the research results:

- What is the readiness of the schools involved in the project to implement the STEM approach in the teaching and learning process?

Based on the research question, the researchers decided to:

- Conduct focus group interviews with principals of the schools involved in the project;
- Conduct focus group interviews with pre-service teachers participating in the project;
- Conduct focus group interviews with in-service and pre-service STEM subject teachers from the participating schools;
- Prepare transcripts of the interviews;
- Identify and categorise codes;
- Analyse the obtained results.

3.4. Results and analysis

In the process of analyzing the research data and identifying the attitudes of the target group members toward the implementation of the STEM approach in formal education, two researchers independently defined and then reconciled the main codes. These codes primarily reflected the participants' perspectives on the introduction of the STEM approach in formal education. They are approximately as follows:

- Knowledge and experience
- Cognitive and emotional response
- Intrinsic motivation
- Openness to gaining new experiences
- Material resources
- Administrative support

- Social and cultural influence
- Expectation of professional development

The codes were identified based on theories of cognition (Kolb, 2014), personality (Rogers, 1995), and social and cultural development (Vygotsky, 1978). These theoretical frameworks generally explain how individuals form attitudes toward various issues. Since STEM education represents a new challenge within the Georgian educational sphere, it was especially important for the researchers to understand respondents' prior (school and post-school) knowledge and experience regarding STEM education. The responses were diverse. For example, students defined STEM education as "the integration of four key subjects—science, technology, engineering, and mathematics, which allows these subjects to be viewed as interconnected and complementary. They also emphasised that STEM promotes professional growth. However, all students (100%) acknowledged that during their school years, there had been no such policy or adequate physical environment to support STEM education. When asked whether their awareness of STEM had increased during their university studies, 85% of students stated that they regularly participate in meetings, visit schools in the frame of STEM clubs, observe teaching processes, and attend webinars on STEM topics, all of which have enhanced their understanding in this area. A small portion of students (8%) noted that they previously lacked knowledge about research design and implementation, and that engagement with STEM education had helped them develop these skills. Only one respondent reported that their awareness had not changed during their university studies. It is noteworthy that almost all students stated they are unable to independently plan and implement a STEM project, which strongly suggests the need for further training and capacity building for students in this direction.

The opinions of school principals (knowledge component) on this issue are similar to those of the students. The majority of respondents (80%) stated that STEM education mainly involves the integration of technology, natural sciences, and mathematics in a complex and interconnected way, which, in their view, contributes to the "development of diverse skills in students." They also emphasized that "STEM involves the integration of subjects that are inherently connected to each other." One respondent highlighted the importance of the collaborative environment that emerges among students during STEM-based activities. Another principal pointed out the rationale behind the STEM abbreviation, noting that it was created "to teach these subjects as a whole, enabling greater transfer of knowledge to real life, so that children do not separate these disciplines but apply them in practical contexts." The survey results clearly indicate that most school principals lack sufficient experience in implementing STEM education within their schools. Only a few schools have taken initial steps in this direction within the framework of the project. Consequently, many principals could provide only limited or no examples of STEM implementation in their institutions. This finding is consistent with the students' responses, which also highlighted the limited practical experience of schools in adopting STEM-based teaching.

Teachers' knowledge in this area is also rather limited. However, a small number of teachers (10%) who have had experience with STEM education in the context of non-formal learning openly shared their professional knowledge and experience. According to their responses, some teachers have established research clubs within their schools, where students develop projects, participate in competitions, and receive work kits as prizes, which they then use to create new projects. Examples include making animated films, constructing traffic lights, and similar creative initiatives. One school even participated in the Leonardo da Vinci competition, where the theme was "Water Ionization through Electric Current." As part of this project, the students built a robot, demonstrating a high level of engagement and innovation. It was also noted that one of the schools had been implementing an EU-funded project since 2021, focused on establishing technology clubs in schools. Within that framework, a technology club operated successfully. After the project ended, teachers expressed a strong desire to continue the club's activities. They were pleased that the university offered a new project that would build upon their existing experience and expand it further—integrating the remaining STEM subjects alongside technology.

Some teachers provided particularly insightful responses when discussing their training, club-based, and professional experiences related to STEM education. They described how interdisciplinary integration between subjects has become easier for them to recognise and implement. Based on their experience, when connections between subjects are made visible to students, their motivation and engagement in the learning process increase significantly. Teachers also emphasised that making mistakes is an essential part of the process — both teachers and students make errors during research projects, and these mistakes become valuable learning opportunities. Through such experiences, teachers reported that they have gained and deepened both theoretical and practical knowledge in the field. Moreover, from a scientific perspective, teachers noted that their intellectual and professional horizons have expanded across various disciplines, particularly in engineering and technology, as a result of their involvement in STEM-related activities.

A particularly interesting theme emerged from the teachers' responses regarding their experience with implementing STEM education. They emphasised that the effectiveness of STEM education lies not only in the integration of different disciplines but also in its strong promotion of teamwork and collaboration. According to their experience, STEM education fosters collaborative learning among students, encouraging them to work effectively in groups. At the same time, the planning and implementation of STEM activities require close cooperation and mutual support among teachers themselves. Many respondents shared examples of successful collaboration with colleagues, highlighting that teamwork among educators is a key factor in the successful realisation of STEM-based teaching.

Since the respondents demonstrated limited knowledge and experience in implementing STEM education, their answers also revealed a high level of cognitive curiosity and emotional engagement toward the topic. They clearly recognized the importance and necessity of introducing STEM education and shared thoughtful insights on how this approach could be effectively implemented. The students' responses were particularly interesting when they described which teaching methods and strategies they considered most effective in promoting STEM-based learning. According to the students, "since STEM education is directly focused on science, technology, engineering, and mathematics, it primarily relies on strategies that foster the development of practical, creative, and problem-solving skills in students. As a result, students learn to solve real-life problems and understand that critical thinking, teamwork, and an interdisciplinary approach should be at the forefront of their learning process." The students' responses clearly demonstrate a moderate to strong level of awareness and a positive attitude toward STEM educational approaches. According to them, "the physical environment should be flexible, inspiring, and supportive so that innovative and collaborative student work can be more easily perceived; the environment must necessarily take into account the students' needs, and only then technological resources and interdisciplinary approaches. Simply put, it should include multifunctional spaces." Although the students still have limited knowledge and experience in implementing STEM education, they speak about this issue with greater emotional engagement and awareness, envisioning its effectiveness in relation to learners: "When children are directly involved in the learning process and actively guide it themselves, the teaching and learning process becomes more effective. The children also see the everyday relevance of these subjects, understand their practical applications, and will use the knowledge and experience gained in their lives." Similar to teachers' responses, they highlight such essential aspects as teamwork, collaboration, critical and creative thinking, and the ability to apply practical research skills, knowledge, and abilities in real-life situations. They do not forget the importance of STEM education in school curricula, and the vast majority of them (99%) confirm the idea of integrating STEM education into the teaching of science subjects in schools. According to them, a student who is equipped from the beginning with both theoretical and practical skills in organising and conducting research, as well as in writing projects, will be better prepared for university life and beyond. Equally emotional are the students' opinions about strengthening the STEAM approach in schools and universities. They note that: "Curriculum renewal and integration will be among the top priorities, which will promote STEM education and bring it to the forefront. In this direction, retraining teachers and students and

involving them in more projects will help advance STEM education. Additionally, integrating technologies can also be one of the priorities. They also add digital platforms, which, in their opinion, are among the key priorities in this regard.

One of the questions asked was the following: In what form should the strengthening of STEM approaches take place in schools, and how do the school principals view their role in this process? The responses from principals suggest that they have a clear understanding of the importance and necessity of implementing STEM education. Therefore, their answers are both thought-provoking and emotional. All respondents initially emphasise academic knowledge, which they believe is essential for achieving any meaningful results. As one principal noted: "In order to introduce something new, we ourselves must first learn it well, both subject teachers and the principal. Teachers need to be equipped with appropriate knowledge in this area, and this was exactly the motivation for our involvement." Respondents wish for such activities to take on a systemic character — for everyone to be involved simultaneously, to undergo appropriate training, and to acquire both theoretical knowledge and practical experience. Several school principals also noted that their schools have included the strengthening of STEM subjects in their mission statements. However, they pointed out that they lack practical experience in this area, or at best, have only experience working within clubs. Therefore, to implement STEM approaches in formal education, they require significant support.

As we anticipated, all ten school principals expressed their readiness to support this approach. Naturally, the most well-reasoned arguments and the strongest willingness to integrate STEM approaches into school curricula came from those principals who already have both international and local experience in implementing such approaches and, therefore, possess a more developed awareness. Moreover, they believe that incorporating STEM will further refine and advance curricula in the fields of science, mathematics, and technology. As one respondent explained: "We definitely think so, because we are in contact with teachers of the relevant subjects and are working on how this can be introduced in physics, chemistry, science, and mathematics. I believe that this will provide even greater motivation for students to study these subjects more effectively."

The responses of school teachers when discussing STEM education are emotionally charged. For 60% of those surveyed, STEM represents a combined approach — the integration of science and technology with engineering, which, in their view, must be implemented in schools because these are precisely the fields that will develop in the future. They believe that students should acquire basic skills in these subjects, which will undoubtedly help them both in choosing future professions and in their professional activities later in life. Most respondents agree that STEM education means presenting information to students in a more complex and interconnected way — fostering an integrated understanding of the natural sciences and providing a more comprehensive perspective overall.

All three categories of respondents in our interviews acknowledged that this is the best way to apply knowledge in practice. They also emphasised that it encourages "learning about new things, enhancing and strengthening collaboration, introducing more activities, especially engaging and enjoyable ones into the learning process, and working through projects." They further highlighted that "the knowledge students gain, for example, in geography, mathematics, biology, chemistry, and physics, combined with the use of technology, can be connected in a way that allows them to design something innovative, such as a device that can automatically solve real-life problems through technology and artificial intelligence."

Among the target teachers, there were a few whose schools already have the resources and experience needed to develop STEM education and to engage more students in related activities. These teachers provided more academically oriented responses. "As I came to the school," one teacher explained, "I found both the material and human resources that allowed us to gain deeper experience in the STEM direction and to conduct more engaging lessons. We all know that students' interest in these subjects somewhat requires reconsideration. By this, I mean that through more practical work, conducting experiments, and hands-on activities, students gain stronger and more lasting knowledge and experience. Also, when integration among subjects takes place, students become more involved, interested, and focused; their internal motivation becomes significantly higher."

As for teachers' attitudes toward integrating STEM education into school curricula, the obtained responses were almost uniform. Since teachers themselves are the main implementers of the STEM approach within schools, it is natural that they approach this issue with caution and in some cases, even with a degree of scepticism, because:

- Teachers must first clearly and fully understand all aspects of this process.
- They should be provided with appropriate resources explaining how integration should take place.
- A proper guide should be developed, containing detailed instructions.
- Everything must, of course, be organically combined by several subject specialists, with age-appropriate adaptation.
- The time factor is also important — how realistic is it to achieve all this within one lesson? Who should conduct it? How should teachers collaborate or pair up?
- It also requires additional effort from the teacher, and so on.

However, teachers also spoke about the positive aspects of integrating this type of teaching into the curriculum:

- "Such activities, where we share our experiences and knowledge with one another, and collaborate, are truly enjoyable. It's nice to make new acquaintances and friends through cooperation, and student engagement in lessons will increase even more."
- "This will be very important, so-called 'invisible' children will have the opportunity to reveal their skills and abilities while working on STEM projects."
- "Some students even remark, 'Why didn't I learn about electricity back then?' Through working with Arduino, they realise how essential it is to have a broad base of knowledge."

Thus, the interviews reveal that representatives of the target group still lack the necessary knowledge and experience to effectively implement STEM education within the educational environment. However, they are fully aware of its importance in increasing students' interest, engagement, and cognitive activity in science subjects and the educational process in general. They themselves are also highly motivated to participate in these processes. To reinforce this point, they speak about the social and cultural impact that the introduction of STEM education could bring about.

The principals of the schools where STEM education has already begun to take root (25%) spoke about the students' enthusiasm and motivation during the implementation of various interesting projects. In their opinion, the natural sciences direction in schools has been "revived." Students actively participate in conferences and competitions and win with their innovative projects—something that used to be rare in the past. It is particularly important that in one of these schools, senior students who already have experience in this field have trained the next generation, who are now leading the club. The respondents (75%) who have not yet had such an experience nevertheless recognise its importance and are showing initiative to get involved in projects in order to improve the teaching of science subjects and, through this, to enhance school life.

Teachers also spoke candidly about this direction, noting that at first it was difficult to understand and implement. However, the enthusiasm of both teachers and students completely changed attitudes toward STEM education, making the learning process more engaging, creative, and goal-oriented. The attitude toward in-depth teaching of STEM subjects has also changed, as it provides teachers with opportunities for growth, self-development, and fostering the better development of their students.

It is particularly noteworthy that teachers emphasised the development of positive collaboration among colleagues, which, in their view, has a beneficial impact on the overall school culture. One of our respondents notes: "We exchange ideas with one another, reach agreement on various topics, or have a 'critical friend' to provide feedback. We share our thoughts and knowledge, discuss everything afterwards, and in this way, we grow every day. Most importantly, students notice this, and it motivates them to collaborate with their peers as well." It was also interesting for us to study students' attitudes. The majority of them stated that

their perspectives had changed positively: "Of course, it has changed, because I am already a fifth-year student. I have completed my module practicums, and during active practice, I tried to use modern technologies, integrate different subjects, and apply the knowledge I gained in practice. We also learned about various platforms for designing activities, which helped raise our awareness." The students also noted that during their school practicums, they did not have the opportunity to gain experience in implementing the STEM approach within formal education.

During the interview process, while studying attitudes toward STEM education, several additional themes emerged, including respondents' perspectives on available resources, their ability to obtain them, administrative support, and openness to innovation. Teachers noted that they struggle significantly because of the lack of proper conditions and materials: "We have to work very hard because there are no proper facilities; resources are very limited." "If the school had real and virtual laboratories, it would be the best. Students would show much greater interest in science subjects. When there is interest, children learn in a completely different way. Resources are extremely important." The responses show that teachers' openness and motivation toward innovation are quite high. Consequently, school principals spoke about how they actively seek different resources from the Ministry, various foundations, and both local and international grant programs to effectively implement STEM education. However, the limited experience of many respondents suggests that schools are not yet taking sufficient steps to attract projects and strengthen laboratory infrastructure. However, as highlighted in the study, there exists a Republican Network of Research Clubs in Georgia, which enables schools to participate in such projects and receive working kits that would allow them to carry out future innovative activities. The necessity of moral support from school principals also emerged as an important factor. Teachers emphasized that the administration's support plays a decisive role in the successful implementation of STEM education.

The students pointed out an issue that we believe is particularly important for those who shape educational policy. "All schools should have access to similar training sessions, because sometimes schools in the regions are disadvantaged in this regard; there is an information vacuum. Sometimes they are unable to travel to the city and attend the training." When discussing how support for STEM education should be strengthened and how they envision this process, respondents from all three target groups provided similar answers. Most of these answers highlight the need for resources and administrative support. We consolidated their ideas and presented them as follows:

- Integrated projects
- Comprehensive information for teachers (training modules, guides, and more)
- Development of resources
- Professional and administrative support
- Creation of STEM-focused teams and organisation of competitions
- Establishment of STEM clubs at the initial stage in as many schools as possible, and strengthening of club-based activities.

When discussing STEM education, the members of the target group, as we anticipated, expressed both a readiness to embrace new approaches and expectations regarding their own professional development. They also confirmed their willingness to implement and further develop STEM education more actively within their professional practice."We believe that this collaboration among colleagues will become more positive, and students will also be more motivated." "We will use it because, to keep up with modern teaching methodologies and not fall behind their development, we must also develop ourselves and follow these challenges."

Thus, our study revealed several particularly interesting aspects: the STEM field is undoubtedly new in Georgia, yet highly prioritised and engaging. The vast majority (80–95%) of respondents across all categories agree that STEM education should be introduced in schools. However, when it comes to integrating it into formal education, they approach the idea with a certain degree of caution, and this attitude has its own objective reasons:

- Lack of experience
- Inadequate infrastructure
- Fear of new approaches
- Excessive effort required, and other factors.

Despite these concerns, respondents believe that STEM education must indeed be introduced in schools. However, at this stage, they consider it preferable for this direction to be established first through non-formal education and only later, gradually, to be integrated into formal education.

4. Conclusion and Recommendations

The study revealed that, despite the limited knowledge and experience, attitudes toward STEM education in schools are clearly positive. All three target groups, school principals, pre-service teachers, and in-service teachers, recognise the importance of STEM education as an essential condition for introducing innovative teaching formats within the modern educational environment.

The study showed that participants have high motivation and readiness to implement STEM approaches in practice; however, several factors hinder this process: insufficient material and technical resources, a lack of instructional and administrative support, and limited experience. Despite these challenges, there is a clear openness to innovation, a willingness to collaborate with the university, and a desire to enhance awareness regarding the integration of STEM education into formal education.

Based on the study findings, it can be stated that STEM education in Georgian schools not only strengthens subject-specific knowledge but also promotes interdisciplinary thinking, teamwork, and the development of critical and creative skills. The readiness demonstrated by participating teachers and students toward the introduction of STEM represents a positive trend that requires systemic support at both the state and institutional levels.

The recommendations were formulated in the study:

- STEM education should be integrated at the level of national strategies, which includes the development of resources, the establishment of laboratories, and the strengthening of schools' material and technical infrastructure.
- Targeted training and retraining programs on STEM approaches are essential, including for schools in the regions.
- A partnership model should be established in which universities, as centres of knowledge, support schools in organising and implementing STEM clubs, innovative projects, and research activities.
- Gradual integration of STEM/STEAM approaches into school and university curricula is recommended, with an emphasis on practical and project-based learning.
- Training for school principals and management is necessary to enable them to support and ensure the sustainable institutional implementation of a STEM culture.
- Sharing successful school practices, expanding national STEM competitions, and developing networks of science clubs are desirable steps that would increase motivation and promote the dissemination of best practices.
- STEM education programs should be accessible to schools of all regions and types, including small and rural schools.

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