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Innovating STEM education: Teacher reflections on challenges, strategies, and development

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Abstract

This study investigates the crucial role of teachers' perspectives in enhancing STEM education, specifically focusing on evaluating existing programs, identifying challenges, and proposing actionable improvements. A comprehensive survey was administered to gather detailed insights from teachers regarding the effectiveness of STEM educational materials and methodologies. The survey results reveal key areas requiring enhancement to better support student learning, particularly in the integration of science, technology, engineering, and mathematics within the curriculum. The findings indicate that incorporating teachers' feedback can lead to substantial improvements in teaching practices, professional development opportunities, and overall student outcomes. The study emphasizes the significance of inclusive education, the importance of hands-on and experiential learning, and the critical role of technology integration in modern STEM curricula. Additionally, it highlights the necessity for targeted professional development programs that are closely aligned with the specific needs and challenges identified by teachers. By applying the firsthand experiences and practical recommendations of teachers, this research aims to inform and influence curriculum development processes, ultimately fostering a more effective and equitable STEM education system. The practical implications of the study suggest that schools and educational institutions can overcome current barriers by adopting these recommendations, thereby improving the STEM learning experience and more effectively preparing students to face future challenges and seize opportunities in the rapidly evolving fields of science and technology.

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1. Introduction

In today's world which is driven by technology, STEM education is very important for preparing young people for future jobs. STEM teaching improves the knowledge in Science, Technology, Engineering, and Math. It also develops many skills like problem-solving, creativity, and teamwork. Communication and adaptability are also key skills that STEM helps to strengthen. These abilities are vital for success in the

global economy. Through projects based on real problems and hands-on experiences, STEM education encourages students to apply what they learn in the classroom to specific life situations and challenges.

STEM education represents an innovative approach in modern education, which methodology is based on the idea that the four disciplines should not be taught in isolation, but as related and interdependent areas that reflect the real world (English, 2016).

At a time when technological advances and scientific discoveries are shaping the future of our society, the importance of education in STEM fields continues to grow. Teachers play an important role in developing students' interest and knowledge in these areas (Margot & Kettler, 2019). Teacher preparation and perceptions are among the key factors in successfully integrating STEM into the school curriculum.

In this context, the study of teachers' opinions about STEM education becomes fundamental. The goal is to understand how teachers evaluate current STEM teaching methods and resources, as well as their suggestions for improvements that could increase the effectiveness of the educational process in these important science areas (Becker & Park, 2011).

One of the primary goals of STEM education is to prepare young people for careers in growing technology sectors and develop the skills they need to succeed in the 21st century (UNESCO, 2019).

Despite the importance of STEM, numerous studies show that many schools struggle to offer enough resources and qualified teachers to meet the growing demands in these fields. Innovative approaches and efforts to improve STEM education are essential to prepare students for future challenges (Al Hamad, Adewusi, Unachukwu, Osawaru, & Chisom, 2024).

The goal of the article is to explore and analyze teachers' opinions on STEM education based on their views, experiences and challenges related to the provision of STEM education in contemporary educational institutions.

1.1. Research Tasks

To achieve the goal, the following tasks must be completed:

- To study the methodological and pedagogical literature on the developed topic.
- To select survey participants and create a survey.
- To carry out the survey.
- To present an objective analysis of the data from the obtained results.
- To interpret the data.
- To offer recommendations for improving STEM education.

1.2. Key Aspects of STEM Education

- Integration: STEM education seeks to integrate Science, Technology, Engineering, and Mathematics to demonstrate their interconnectedness and applicability to real-world situations. As educators, it is crucial to understand that academic subjects should be interconnected rather than taught in isolation. Students need the ability to apply their learning across different subjects and make connections that enhance their academic performance (Becker & Park, 2011).
- Inclusive education STEM education strives to be inclusive and provide equal opportunities for all students, regardless of their socioeconomic status, gender, or ethnicity. This includes developing programs to attract and retain diverse groups of students in STEM fields (Palid, Cashdollar, Deangelo, Chu, & Bates, 2023).
- Critical thinking and problem-solving are important in today's education. Teachers see the need to handle real-life problems. This understanding has led to many studies to help improve these skills (Ardianti, Sulisworo, Pramudya, & Raharjo, 2020; Mohottala, 2016).
- Multidisciplinarity: Multidisciplinarity in STEM education means combining different science and tech subjects into one program. This helps students deal with real-world problems and improves their thinking and creativity. It also shows them how different subjects are connected and how to use them to solve problems (Hallström, Norström, & Schönborn, 2023).
- Practical applicability: STEM lessons aim to be useful in real-life situations to help students get ready for future job challenges (Aslam, Alghamdi, Abid, & Kumar, 2023).
- Teamwork: This is an essential aspect of STEM projects, supporting the development of communication skills, leadership and collaboration among students. This approach encourages the sharing of knowledge & skills, and helps students learn how to work together to solve complex problems (Shofiyah, Wulandari, Mauliana, & Pambayun, 2022).

STEM education helps students prepare for their future in a tech-based world by teaching them the basics of science and technology. It gives them the skills they need to understand and use technology in everyday life (Kelley & Knowles, 2016).

1.3. Advantages of Surveying Teachers' Views on STEM Education

- Improving Teaching Practices: Understanding teachers' opinions can help identify successful practices and improve teaching methods in STEM. This may include providing additional training or resources for teachers who express a need for support (Salzman & Lieff Benderly, 2019).
- Supporting Educational Development: Teachers' opinions can be an important factor in determining future directions and development of STEM education. Understanding their views and preferences can help formulate policies and programs for the development of the educational system (Ifenthaler, 2012).
- Improving Professional Development: Teachers can point out areas where they need more training, like teaching methods or specific STEM subjects. Survey results help create focused training programs (Desimone, 2009).
- Improving Student Outcomes: Teachers work closely with students and know how different methods impact their success. By looking at teachers' opinions, new strategies can be created to boost student interest and success in STEM subjects (Salzman & Lieff Benderly, 2019).
- Evaluating the effectiveness of current programs: Teacher opinion surveys help evaluate current STEM programs and teaching materials. Teachers give feedback on what works well and what needs improvement. This helps make the learning process better and more suited to students' needs (Darling-Hammond, Hyler, & Gardner, 2017).
- Understanding real challenges and needs: Looking at teachers' opinions can show the challenges and needs in STEM education. This might include not having enough resources, trouble using technology, or difficulties in motivating students. These issues can then be addressed and solved (Ejiwale, 2013).
- Identifying challenges and support needs: The goal is to find out what obstacles teachers face in implementing STEM education and what support or resources they need to overcome them (Ejiwale, 2013).

2. Research Methods

To choose how to collect and analyze data when asking teachers about STEM education is very important to receive good results.

Surveys: This method keeps teachers anonymous and help them to share their thoughts freely. Surveys also collect data in the same way, making it easier to analyze and compare the results.

3. Results and Discussion

STEM education is playing a bigger role in today's schools. This survey aims to understand teachers' views and experiences with teaching STEM subjects.

Even though STEM education has many clear benefits, listening to teachers' opinions is key to making it work and grow successfully. Since teachers work with students every day and use new teaching methods directly, their thoughts and experiences help us understand the real challenges and opportunities that come with STEM education.

For the research, we conducted a survey with teachers from different schools. Through analysis of the collected data, we offer recommendations to improve support and resources for teachers, as well as to overcome identified barriers to the successful implementation of STEM education.

The survey was created to gather data and feedback from teachers to better understand the challenges and opportunities associated with implementing STEM learning in schools. Participation in the survey "Teachers' opinion survey on STEM education" took 60 teachers from the following schools: Henry Ford School of Transportation and Energy, Sofia; John Atanasov Vocational High School of Electronics, Sofia; Vocational High school of Transport, Sofia; Foreign Language High School "Acad. Lyudmil Stoyanov", Blagoevgrad, Secondary General Education School with study of foreign languages "St. Kliment Ohridski", Blagoevgrad and 7th Secondary School "Kuzman Shapkarev", Blagoevgrad. The survey was filled in on paper, then processed via google forms.

Table 1. Illustrates the age distribution among the respondents.

Age group	%
Under 30	10 %
30 – 40 years old	40 %
41 - 50 years old	23.3 %
51 years old or more	26.7 %

This Table 1 presents the distribution of ages among the respondents in the survey.

4. Survey Results and Findings

4.1. What is Your Age Group?

The survey shows varied representation across age groups. Only 10% of respondents are under 30, indicating young teachers are less represented but more open to adopting new technologies like STEM. The largest segment, at 40%, is teachers aged 31-40, who are in their prime career and most active in the survey, showing a balanced mix of experience and innovation readiness. Teachers aged 41-50, making up 23.3%, have significant experience but might need extra support to embrace new methods. Finally, those over 51 years, comprising 26.7%, possess the most experience but could face challenges with new technologies, benefiting from specialized support for STEM integration.

Table 2. Highlights the willingness to integrate STEM learning into the lessons.

Willingness for integration	%
Low willingness	13.3 %
Average willingness	30 %
High willingness	56.7 %

This Table 2 presents the levels of willingness among respondents to integrate STEM learning into their lessons.

4.2. What Is Your Willingness to Integrate STEM Learning into Your Lessons?

Survey results on willingness to integrate STEM education show varied levels of readiness among teachers. Only 13.3% exhibit low willingness, likely due to insufficient STEM knowledge, resources, or administrative support, highlighting a need for specialized training. About 30% show average willingness, indicating interest but requiring additional training and support to effectively implement STEM methods. Encouragingly, 56.7% demonstrate high willingness, suggesting strong acceptance and support for STEM practices, likely influenced by increased interest in modern educational practices and available resources.

Table 3. Represents the main challenges in teaching STEM subjects.

Main challenges	%
Lack of resources and equipment	46.67 %
Lack of training and preparation	20 %
Organization and coordination	13.33 %
Specific problems at work	10 %
Other challenges	10 %

This Table 3 presents the primary challenges faced by respondents in teaching STEM subjects.

4.3. What Are the Primary Challenges You Encounter when Teaching STEM Subjects?

The primary challenges identified in teaching STEM subjects are led by a lack of resources and equipment, which affects 46.67% of respondents. Following this, 20% of teachers cite a lack of training and preparation as a significant hurdle. Organizational and coordination issues impact 13.33% of respondents, while specific work-related problems are a concern for 10%. Additionally, another 10% of teachers report facing various other challenges. These findings suggest that addressing resource shortages, enhancing teacher training, and improving organizational structures are critical steps toward improving STEM education.

Table 4. Shows the technology role in STEM curriculum.

Technology role	%
Does not play any role	23.8 %
Additional role	52.4 %
Main role	9.5 %
Crucial role	14.3 %

This Table 4 presents the perceived role of technology in the STEM curriculum according to the respondents.

4.4. What Role Does Technology Have in Your STEM Curriculum?

The survey on the role of technology in the STEM curriculum reveals diverse levels of integration. A significant portion, 52.4%, indicates that technology plays an additional role in their curriculum. Meanwhile, 23.8% of respondents report that technology does not play any role at all. For 14.3% of the participants, technology is seen as crucial in their STEM curriculum, whereas 9.5% consider it to play the main role. These results suggest varying degrees of reliance on technology, with a majority recognizing its supplementary

value, but also highlight that a notable fraction of educators either underutilize or do not incorporate technology in their STEM teaching.

Table 5. Emphasizes the importance of STEM education in preparing students for the future.

Importance	%
Not important	0 %
Unspecified	30 %
Important	33.3 %
Very important	36.7 %

This Table 5 presents the respondents' views on the importance of STEM education in preparing students for the future.

4.5. What are Your Thoughts on the Importance of STEM Education in Preparing Students for the Future?

Regarding the importance of STEM education in preparing students for the future, none of the respondents considered it unimportant. However, 30% did not specify their views. Among the remaining participants, 33.3% believe that STEM education is important, while a larger portion, 36.7%, view it as very important. These findings indicate a strong consensus on the significance of STEM education in equipping students with essential skills for future success, with the majority recognizing its critical role.

Table 6. Evaluates the students' interest and engagement in STEM lessons.

Evaluation	%
Poor rating	10 %
Satisfactory rating	20 %
Good rating	40 %
Excellent rating	30 %

This Table 6 presents the evaluation of students' interest and engagement in STEM lessons according to the respondents.

4.6. What is Your Evaluation of Students' Interest and Engagement in STEM Lessons?

The evaluation of students' interest and engagement in STEM lessons shows varied levels of enthusiasm. A small percentage, 10%, rate student engagement as poor, while 20% find it satisfactory. A larger portion, 40%, rate it as good, and 30% consider it excellent. These results indicate that the majority of students are positively engaged in STEM lessons, with a significant number showing high levels of interest and participation.

Table 7. Incorporates the teamwork and team learning within STEM education.

Incorporation of STEM education	%
I do not apply it	10 %
I rarely use it	10 %
I allow it but do not actively encourage it	23.3 %
I actively encourage it	56.7 %

This Table 7 presents the extent to which teamwork and team learning are incorporated within STEM education according to the respondents.

4.7. How do You Incorporate Teamwork and Collaborative Learning in STEM Education?

Regarding the incorporation of teamwork and collaborative learning in STEM education, 10% of respondents do not apply it at all, and another 10% rarely use it. Meanwhile, 23.3% allow teamwork but do not actively encourage it. The majority, 56.7%, actively encourage teamwork and collaborative learning in their STEM education practices. This indicates a strong emphasis on collaborative approaches in STEM, with over half of the educators promoting teamwork actively.

Table 8. Outlines the methods for engaging students in STEM lessons.

Methods	%
Practical trials and experiments	33.3 %
Use of technologies (Software and hardware)	36.7 %
Group workshops and projects	30 %
Other	0 %

This Table 8 presents the methods used by respondents to engage students in STEM lessons.

4.8. What are the Most Effective Methods You Have used to Engage Students in STEM Lessons?

The most effective methods for engaging students in STEM lessons, according to the survey, include practical trials and experiments, used by 33.3% of respondents. The use of technologies, both software and hardware, is the most popular method, employed by 36.7% of teachers. Group workshops and projects are also effective, with 30% of educators utilizing this approach. Notably, no respondents reported using other methods. These findings highlight a preference for hands-on, technology-integrated, and collaborative approaches to enhance student engagement in STEM education.

Table 9. Presents the students' interest in STEM subjects since the implementation of STEM education.

Students' interest	%
I can't notice changes	23.3 %
No, the interest remained the same	10 %
Yes, the interest increased	66.7 %

This Table 9 presents the changes in students' interest in STEM subjects since the implementation of STEM education according to the respondents.

4.9. Have You Observed Changes in Students' Interest in STEM Subjects Since the Implementation of STEM Education?

Since the implementation of STEM education, the survey shows notable changes in students' interest in STEM subjects. A significant majority, 66.7%, report an increase in interest. Meanwhile, 23.3% of respondents have not noticed any changes, and 10% believe that the interest has remained the same. These results suggest that STEM education has generally had a positive impact on student engagement, with most educators observing increased interest in STEM subjects.

Table 10. Reviews the adaptiveness to new educational trends related to technology and STEM learning.

Adaptiveness	%
I am not willing to make changes	6.7 %
I accept them, but do not apply them	10 %
I research them before applying them	53.3 %
I immediately accept them	30 %

This Table 10 presents the respondents' adaptiveness to new educational trends related to technology and STEM learning.

4.10. How do You Adapt to New Educational Trends in Technology and STEM Learning?

The survey results on adaptiveness to new educational trends in technology and STEM learning indicate varying levels of willingness to change. A small percentage, 6.7%, are not willing to make changes, while 10% accept new trends but do not apply them. The majority, 53.3%, prefer to research new trends before implementing them. Meanwhile, 30% immediately accept and apply new educational trends. These findings suggest that while most educators are open to adapting to new trends, they prefer to thoroughly evaluate them before integration, ensuring they are beneficial for their teaching practices.

Table 11. Reveals the additional resources for enhancing STEM curriculum.

Additional resources	%
Educational software	23.3 %
Laboratory equipment	33.3 %
Professional trainings and seminars	23.4 %
Financial support for projects	20 %
Other	0 %

This Table 11 presents the additional resources identified by respondents as necessary for enhancing the STEM curriculum.

4.11. What Additional Resources Would You Like to Have to Enhance Your STEM Curriculum?

To enhance the STEM curriculum, educators have expressed a need for various additional resources. Laboratory equipment tops the list, with 33.3% of respondents highlighting its importance. Educational software is also in high demand, requested by 23.3% of teachers. Professional training and seminars are equally valued, with 23.4% indicating a need for these to improve their skills and knowledge. Additionally,

20% of respondents seek financial support for projects. Notably, no respondents selected other resources, suggesting these categories cover the primary needs for enhancing STEM education.

Table 12. Represents the suggestions and recommendations for improving STEM learning.

Additional resources	%
Funding and resources	20 %
Purchase of equipment and machinery	33.3 %
Training and professional development	20 %
Development of educational materials and programs	20 %
Subscriptions to educational products	6.67 %

This Table 12 presents the suggestions and recommendations made by respondents for improving STEM learning.

4.12. What Suggestions or Recommendations do You Have for Improving STEM Learning at Your School/Institution?

To improve STEM learning, educators have provided several key suggestions. The most significant recommendation, cited by 33.3% of respondents, is the purchase of equipment and machinery to better support hands-on learning. Funding and resources, as well as training and professional development, are each recommended by 20% of participants, highlighting the need for financial support and ongoing educator training. Another 20% emphasize the development of educational materials and programs. Finally, 6.67% of respondents suggest subscriptions to educational products. These recommendations indicate a clear demand for better resources, financial investment, and continuous professional growth to enhance STEM education.

5. Conclusion

The survey presents different experiences in integrating science and technology into teaching. Many teachers want to use STEM methods, but sometimes they face obstacles like not enough resources, lack of lab equipment, modern tools, and training. This shows a need for more specific support and investment.

Some recommendations include to be invested in modern lab equipment, which offers regular teacher training, and increasing funding for STEM projects. Other suggestions are to create digital lessons, promote student teamwork, and add more activities. These will improve the quality of STEM education and prepare students better for future challenges. Teachers, schools, and institutions must work together for successful STEM integration.

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Appendix 1. Presents the survey questions.

Survey: Teachers' opinion on STEM education

Thank you for participating in our survey. Your responses are very important to us. Please note that all your responses will remain anonymous and solely used for the purpose of this research.

1. What is your age group?
   - Under 30
   - 30 – 40 years old
   - 41 - 50 years old
   - 51 years old or more
2. What is your willingness to integrate STEM learning into your lessons?
   - Low willingness
   - Average willingness
   - High willingness
3. What are the primary challenges you encounter when teaching STEM subjects?
   - Lack of resources and equipment
   - Lack of training and preparation
   - Organization and coordination
   - Specific problems at work
   - Other challenges
4. What role does technology have in your STEM curriculum?
   - Does not play any role
   - Additional role
   - Main role
   - Crucial role
5. What are your thoughts on the importance of STEM education in preparing students for the future?
   - Not important
   - Unspecified
   - Important
   - Very important
6. What is your evaluation of students' interest and engagement in STEM lessons?
   - Poor rating
   - Satisfactory rating
   - Good rating
   - Excellent rating
7. How do you incorporate teamwork and collaborative learning in STEM education?
   - I do not apply it
   - I rarely use it
   - I allow it but do not actively encourage it
   - I actively encourage it
8. What are the most effective methods you have used to engage students in STEM lessons?
   - Practical trials and experiments
   - Use of technologies (Software and hardware)
   - Group workshops and projects
   - Other
9. Have you observed changes in students' interest in STEM subjects since the implementation of STEM education?

- I can't notice changes
- No, the interest remained the same
- Yes, the interest increased

10. How do you adapt to new educational trends in technology and STEM learning?

- I am not willing to make changes
- I accept them, but do not apply them
- I research them before applying them
- I immediately accept them

11. What additional resources would you like to have to enhance your STEM curriculum?

- Educational software
- Laboratory equipment
- Professional trainings and seminars
- Financial support for projects

12. What suggestions or recommendations do you have for improving STEM learning at your school/Institution?

- Funding and resources
- Purchase of equipment and machinery
- Training and professional development
- Development of educational materials and programs
- Subscriptions to educational products