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Teachers' Conceptual Awareness about the Use of STEM Education Practices at Secondary School Level

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Abstract

The study investigates how teachers in secondary schools understand the implementation of Science Technology Engineering and Mathematics STEM educational practices. The effective implementation of STEM education depends on teachers' understanding and their actual classroom applications of STEM educational practices because these practices determine how students will become involved in learning. The research employs a qualitative approach, utilizing interviews and surveys to gather data from a sample of secondary school teachers. The study investigates teachers' understanding of the core principles and components of STEM education their perceived benefits and challenges in integrating STEM practices into their teaching as well as their professional development needs in this domain. The preliminary results show that teachers have a basic understanding of STEM education but they do not understand how to apply STEM education in real classroom situations. The majority of teachers express their inability to use STEM practices in their teaching because schools do not provide them with proper guidelines and necessary resources and sufficient training. The teachers identified various obstacles which included restricted time and educational program limitations and difficulties in obtaining technological equipment and educational resources. Teachers recognize the potential of STEM education in promoting critical thinking problem solving collaboration and creativity among students. However, they require additional support including appropriate training and professional development opportunities access to resources and guidance to effectively implement STEM practices.

Keywords: STEM, SSL, Education, Pakistan

Introduction

The advancement of a nation is fundamentally linked to the development of its human capital, and in the contemporary global economy, high-quality education is regarded as a central driver of sustainable growth. In recent decades, Science, Technology, Engineering, and Mathematics

(STEM) education has increasingly replaced traditional science instruction, reflecting the growing demand for interdisciplinary knowledge and practical competencies. STEM education emphasizes the integration of these four disciplines and promotes cooperative learning approaches that highlight teamwork, problem-solving, and innovation. The primary objective of this approach is to prepare learners for future careers as innovators and professionals by providing hands-on, experiential learning opportunities (Akram & Asiroglu, 2018). In an era characterized by rapid technological transformation, educational systems must evolve to maintain technological competitiveness in the global marketplace.

STEM education is designed to equip individuals with the skills required to solve complex real-world problems. By nurturing creativity and leveraging learners' strengths, STEM initiatives aim to prepare students for emerging career opportunities. Projections indicate a significant expansion of STEM-related occupations both domestically and internationally, with estimates suggesting that a substantial proportion of future employment will require STEM knowledge and competencies (Akram & Asiroglu, 2018). The integration of modern Information and Communication Technology (ICT) tools has fundamentally transformed traditional instructional practices. Studies conducted in higher education institutions demonstrate that contemporary ICT tools play a vital role in enhancing teaching and learning processes.

Research highlights the significant role of ICT devices in professional and educational environments. According to Audi et al. (2021), ICT has reshaped communication patterns and workplace practices, influencing both social interaction and business operations. Numerous empirical studies have examined the effectiveness of ICT tools in classroom settings and explored teachers' perceptions of their usefulness in facilitating instruction (Hevko, 2019; Celebi, 2019; Islahi & Nasrin, 2019). ICT encompasses a broad range of electronic tools used for collecting, processing, storing, distributing, and presenting information. These tools include computer systems, advanced software applications, mobile technologies such as Android applications, satellite communication systems, and wireless internet infrastructure (Roy, 2015). The integration of these technologies into classroom instruction has prompted educators to seek innovative strategies for creating engaging and learner-centered environments.

STEM, as a collective term for science, technology, engineering, and mathematics, represents both academic study and professional practice within these fields. However, research indicates ongoing challenges in STEM education. Hernandez et al. (2013) report that a significant proportion of secondary school students struggle to achieve proficiency in mathematics and science, raising concerns about educational quality. Furthermore, Brown (2012) emphasizes the variability and lack of consensus in defining STEM education, highlighting the need for clearer conceptual frameworks.

Technological advancements and the expansion of human knowledge have exerted a dual influence on education in the twenty-first century (Williams & Kingham, 2003). Education researchers widely acknowledge the necessity of integrating technology into instructional contexts to promote effective and long-term learning outcomes (Komis, Ergazaki, & Zogza, 2007). The use of technology in education extends beyond basic computer use or internet access. It includes the purposeful integration of digital tools and technological resources into pedagogical practices (Isman, 2002). Technology should be viewed not merely as a tool but as a means of enhancing both student academic achievement and teacher professional productivity (Hernandez-Ramos, 2005). In this sense, technology facilitates information exchange and meaningful human interaction, thereby enriching the learning process (Girginer & Ozkul, 2004).

Professional development for science teachers is widely recognized as a critical component of successful STEM implementation. The National Research Council (NRC, 2015) identifies key characteristics of effective professional development, including focused instructional strategies, reflective practice, scaffolded learning, and analytical tools that support content-based instruction. Despite growing interest in inquiry-based STEM curricula aligned with the Next Generation Science Standards (NGSS), there remains limited empirical evidence regarding their effectiveness in fostering student interest and preparing learners for STEM careers (NRC, 2014; Mahoney, 2010). Additional challenges include insufficient professional development opportunities and misalignment between curricula and established standards (Shin & Top, 2015).

Program evaluation in STEM education must also consider the affective domain, as research demonstrates a strong relationship between students' interest in STEM subjects and their decisions to pursue related degrees and careers (Berlin & White, 2012; Mahoney, 2010). Moreover, teacher professional development has been shown to correlate positively with student achievement, underscoring the importance of research-informed training programs (NRC, 2013; Scott, 2012). Currently, there is a shortage of comprehensive data on NGSS-aligned STEM curricula and newly established STEM programs, resulting in a significant research gap (Darling-Hammond, 2000; Whitworth & Chiu, 2015).

According to the United States Department of Education (2007), the America COMPETES Act of 2007 was enacted to strengthen national innovation by investing in research, development, and education in science and technology. The Act aimed to enhance the global competitiveness of the United States by promoting coordination among federal agencies engaged in scientific research and by increasing emphasis on STEM education and workforce preparation. A central objective of the legislation was to ensure that the American workforce remained competitive in an increasingly technology-driven global economy. As a result, many states began adopting federally supported STEM initiatives, and some of the first specialized STEM schools emerged, offering advanced curricula and focusing on preparing students for careers in science, technology, engineering, and mathematics.

Following the passage of the America COMPETES Act, President Barack Obama introduced the Race to the Top initiative in 2009–2010 (U.S. Department of Education, 2009). This program functioned as a competitive grant system in which states could receive federal funding by meeting specific education reform criteria, with STEM education identified as a priority area. States were evaluated based on multiple indicators, including teacher effectiveness, academic standards and assessments, reduction of achievement gaps, improvements in data systems, and prioritization of STEM readiness. Consequently, many states adopted new STEM-focused policies or strengthened existing programs to improve their eligibility for funding. Several states also introduced formal criteria for schools seeking STEM designation, established accountability mechanisms for evaluating student achievement, and emphasized high-quality teacher preparation in K–12 education.

Concerns about American students' academic performance in comparison to other global competitors further intensified the push for STEM reform (Bybee, 2010; Zuger, 2012). At the same time, the growing demand for STEM professionals and the rapid expansion of STEM-related occupations highlighted the urgency of educational transformation. According to the U.S. Bureau of Labor Statistics, there were approximately 8.6 million STEM jobs in the United States, with nearly 70% involving significant computer-related tasks (Fayer, Lacey, & Watson, 2017). Furthermore, about 93% of STEM occupations offered wages above the national average (p. 2). Since 2009, STEM fields have experienced substantial growth, with projections indicating a 28.2% increase by 2024 (Fayer et al., 2017, p. 7). These labor market trends explain why federal policymakers prioritized STEM education and why its relevance extends beyond the United States to the global context, where technological advancement increasingly shapes employment opportunities.

STEM education is commonly defined as an interdisciplinary approach that integrates science, technology, engineering, and mathematics through constructivist teaching practices (Bybee, 2010). Rather than treating these disciplines as isolated subjects, STEM education encourages students to apply mathematical and scientific knowledge to solve real-world problems using engineering design processes and technological tools. Pardue and McGehee (2015) emphasize that the primary goal of STEM education is to cultivate understanding of scientific and engineering principles that drive innovation and societal progress. This approach aligns with the development of "21st-century skills," including critical thinking, creativity, collaboration, and problem-solving (Bybee, 2010).

Student-centered learning is a fundamental feature of STEM pedagogy, where teachers facilitate the connection between students' prior knowledge and new conceptual understanding. This instructional philosophy is supported by research synthesized in How People Learn, which highlights the importance of active learning, inquiry, and reflective practice in promoting meaningful understanding (National Research Council, 2000). Through inquiry-based learning and problem-solving tasks, students are encouraged to think analytically and apply knowledge across disciplines.

Many STEM schools were established in response to federal initiatives such as Race to the Top (U.S. Department of Education, 2009). To receive official recognition or certification as STEM schools, institutions often had to meet state-specific criteria, including implementation of approved STEM curricula, achievement of standardized test benchmarks in mathematics and science, and adoption of a school-wide STEM focus (Carmichael, 2017). Although requirements vary by state, most STEM schools emphasize one or more STEM disciplines while integrating the others, or they adopt a fully integrated interdisciplinary model. Their curricula typically prioritize critical thinking, inquiry, and applied problem-solving, preparing graduates for participation in the STEM workforce.

Given that STEM schools represent a relatively recent development in the U.S. education system, continued research is necessary to better understand the essential characteristics of effective STEM curricula and the professional competencies required of teachers in these settings. Such research contributes to refining policy implementation and ensuring that STEM education fulfills its intended role in fostering innovation, workforce readiness, and long-term economic competitiveness.

Literature Review

Historically significant studies on STEM (Science, Technology, Engineering, and Mathematics) education have been conducted worldwide by professional organizations and research bodies such as the National Science Teachers Association (2020) and the Central Research Office (2014). A major argument supporting STEM education is that professionals in science, innovation, engineering, and mathematics contribute directly to national economic growth and global competitiveness. STEM education is also considered essential for developing scientifically literate citizens, technically skilled professionals, and future innovators.

Recent reforms in the United States have emphasized integrating engineering design practices into science education, reflecting a paradigm shift in how scientific disciplines are coordinated within educational programs. This transformation is evident in the Next Generation Science Standards, which incorporate scientific inquiry, crosscutting concepts, and engineering design as core components of instruction. Such reforms aim to promote interdisciplinary understanding and real-world problem-solving skills among students.

Numerous funding agencies, research centers, and academic journals have prioritized STEM education as a central focus area. For example, the International Journal of STEM Education serves as a global platform for disseminating peer-reviewed research on effective STEM curriculum development and pedagogical innovation from pre-kindergarten to secondary education. These scholarly efforts highlight the growing recognition of STEM education as a strategic priority worldwide.

A key theoretical component within science education is the Nature of Science (NOS). Scholars argue that understanding NOS is fundamental to achieving scientific literacy. However, research indicates persistent confusion between research-based findings and curriculum implementation regarding NOS (McComas & Olson, 2002; Olson, 2018). Although NOS is often described as a high-level instructional objective, it is not consistently articulated as an explicit learning outcome in many science education programs. This gap between theory and practice reflects broader challenges in translating STEM research into classroom instruction.

International organizations and non-governmental bodies have also expressed concern about weaknesses in instructional frameworks and curriculum implementation, particularly in developing countries. In Pakistan, disparities in school distribution and resource allocation continue to affect educational quality. Reports indicate that low literacy and proficiency rates highlight the urgent need for reform in science and mathematics education. Furthermore, the availability and organization of STEM-focused classrooms remain uneven across rural and urban regions, contributing to inequitable access to quality STEM learning opportunities.

According to Bybee (2010), STEM is commonly used as an umbrella term for educational programs that integrate science, technology, engineering, and mathematics to address complex societal challenges. Innovation significantly shapes modern life; however, public understanding of technological systems remains limited (Bybee, 2010). STEM programs provide opportunities for students to develop 21st-century competencies, including adaptability, complex communication, collaboration, non-routine problem-solving, self-management, and systems thinking. These competencies are strongly emphasized in reports by the National Research Council (2010), which link STEM education to the development of higher-order cognitive skills.

Bybee (2010) further suggests that STEM represents a coordinated curricular approach aimed at addressing major global issues such as energy sustainability, resource management, environmental quality, and risk mitigation. Similarly, the United States Department of Education highlights that in an increasingly complex and knowledge-driven world, success depends not merely on possessing information but on effectively applying and managing knowledge. STEM education is therefore designed to equip students with the analytical and evaluative skills necessary to solve real-world problems.

Saad (2015) expands this perspective by emphasizing the importance of collaboration between educational institutions and industry sectors. Cooperative initiatives such as internships, industry-linked projects, and professional training programs are identified as effective strategies for bridging the gap between theoretical knowledge and practical application. These partnerships enhance students' readiness for STEM careers and strengthen the alignment between education and workforce demands.

Overall, the literature demonstrates that STEM education is globally recognized as a transformative approach to preparing students for technological advancement and economic development. However, challenges remain in curriculum alignment, teacher preparedness, equitable resource distribution, and effective integration of interdisciplinary practices. These gaps underscore the importance of further research, particularly in understanding teachers' conceptual awareness and its role in implementing STEM education effectively at the secondary school level.

Rationale of the Study

This study is significant because it investigates the role of teachers' conceptual awareness in the implementation of STEM education practices at the secondary school level. A review of relevant literature indicates a limited body of empirical research focusing specifically on teachers' conceptual understanding of STEM and its practical application in secondary education. While numerous studies discuss STEM policies, curriculum reforms, and student outcomes, fewer studies examine how teachers' knowledge and perceptions influence the effective integration of STEM methodologies in classrooms (Bybee, 2010; National Research Council [NRC], 2014).

Teachers play a central role in translating educational reforms into classroom practice. Therefore, understanding their conceptual awareness is essential for ensuring meaningful implementation of interdisciplinary and inquiry-based STEM approaches. The findings of this study are expected to benefit educational researchers, policymakers, curriculum developers, and practicing teachers. Furthermore, the study may contribute to professional development initiatives designed to enhance instructional practices and improve student learning outcomes. It may also provide valuable insights for higher education institutions involved in teacher preparation programs. Ultimately, the results can support policymakers and educators in evaluating and implementing effective STEM strategies and assist curriculum planners in designing future courses aligned with contemporary educational demands.

Statement of the Problem

Despite the increasing emphasis on STEM education at national and international levels, the effective implementation of STEM practices largely depends on teachers' conceptual awareness and readiness. However, limited research has examined how secondary school teachers understand STEM education and how their awareness influences its classroom application.

Therefore, this study aims to investigate the role of teachers' conceptual awareness in the use of STEM education practices at the secondary school level.

Objectives of the Study

The study seeks to achieve the following objectives:

1. To determine the level of awareness among secondary school teachers regarding the use of STEM-based education.
2. To explore the challenges faced by teachers in implementing STEM education practices.
3. To examine the relationship between teachers' conceptual awareness and their use of STEM education at the secondary school level.

Research Questions

The following research questions were formulated to achieve the objectives of the study:

1. What is the level of secondary school teachers' awareness regarding the use of STEM-based education?
2. What challenges do teachers face in implementing STEM education practices?
3. What is the relationship between teachers' conceptual awareness and their use of STEM education at the secondary school level?

Significance of the Study

The study examining teachers' conceptual awareness of STEM education practices at the secondary school level is significant for several reasons.

First, it contributes to addressing educational disparities by identifying challenges and opportunities in creating equitable and inclusive learning environments for students from diverse backgrounds. Research suggests that effective STEM integration can promote equal access to high-quality education and prepare students for future workforce demands (Bybee, 2010; NRC, 2014).

Second, the study may enhance teacher practice by providing insights into how educators can integrate STEM approaches into their instructional methods. By identifying gaps in conceptual understanding, professional development programs can be designed to strengthen teachers' competencies and improve student achievement.
Third, the findings can inform policy and practice at local, state, and national levels. Policymakers can use the results to refine STEM implementation strategies, allocate resources effectively, and establish supportive frameworks for schools. Curriculum planners may also benefit from the study by identifying best practices and areas requiring improvement in STEM program design and implementation.

Scope and Limitations of the Study

The scope of this study is limited to examining teachers' conceptual awareness and its role in implementing STEM education practices at the secondary school level (Grades 6–12). The research focuses on identifying challenges, opportunities, and effective strategies for integrating STEM into culturally responsive and diverse classroom environments.
The study includes a review of relevant literature on STEM education, as well as data collected through surveys and interviews with teachers, administrators, and students in both rural and urban settings.
However, certain limitations must be acknowledged. First, the study is constrained by available resources and access to participants, which may limit the generalizability of the findings. Second, the research is confined to the secondary education level and does not include primary or higher education institutions. Third, responses collected through surveys and interviews may be influenced by participants' personal perceptions and experiences, which could introduce subjectivity.
Despite these limitations, the study provides valuable insights into the role of teachers' conceptual awareness in strengthening STEM education practices at the secondary school level.

Research Methodology

Research Design

Research design refers to the overall plan and structure that guides the collection, measurement, and analysis of data in a study. According to Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell, a research design provides a blueprint for conducting research in a systematic and organized manner.
This study employed a quantitative survey-based research design. A structured questionnaire was developed and administered to collect data from respondents. The quantitative approach was selected because it allows researchers to measure variables numerically, analyze relationships statistically, and draw generalizable conclusions (Creswell, 2014). Survey research is particularly appropriate when investigating attitudes, perceptions, and awareness levels among a defined population.

Population of the Study

The population of the study consisted of all secondary school teachers and students in District Layyah. District Layyah is located in the province of Punjab, Pakistan.
The target population specifically included teachers teaching at the secondary school level (Grades 6–12). The inclusion of this population ensured that the data collected reflected the conceptual awareness and implementation practices of STEM education among educators directly involved in secondary-level instruction.

Sr.NoTehsil	Male Teachers	Female Teachers
1Layyah	1400	1800
2Karor	1643	1400
3Chobara1200		1100
Total		8543

Sampling Technique and Sample Selection

Theresearcherwaschoosingsampleofthestudybyusingthesampling technique simplerandom

Variable	Category	Frequency	Percentage
Gender	Male	125	50%
	Female	125	50%
	Total	250	100%
Designation	PST	84	33.6%
	EST	120	48.0%
	SST	46	18.4%
	Total	250	100%

Research Tool

In this research a questionnaire was developed with the help of literature review and subject experts. QuestionnairedevelopswiththehelpofFivepointLikert scale was used as the data collection tool.

Validation of Research Tool

Toensurevalidityofresearchtoolresearcherwasgetexpertopinionandconduct pilot study.

Reliability of Tool

To ensure reliability researchers use Cronbach Alpha Test.

Data collection

Researcherherselfwascollectdatafromrespondentsbyvisitingschools.

Data Analysis Techniques

Descriptive and inferential statistics were used in the analysis of the data. Methods from the field of statistics, such as frequency, percentage, mean, standard deviation, and Pearson correlation, were utilized.

Data Analysis and Interpretation of Data

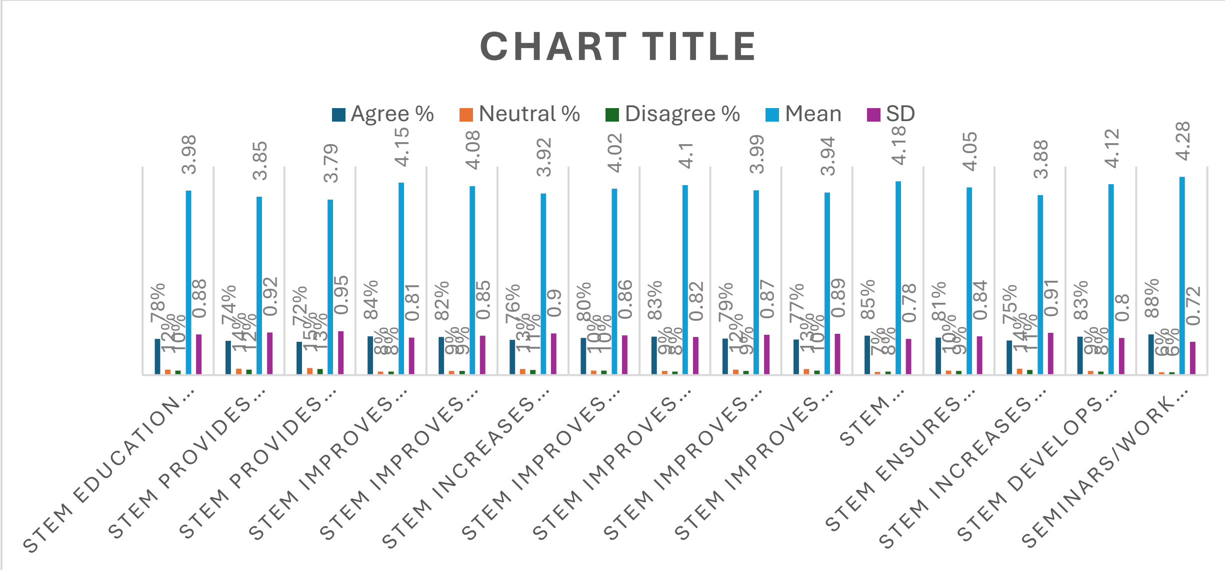
This section of the study presents the data analysis procedures adopted for the research. For clarity and better understanding, the information is organized in tabular form. The first part outlines the demographic characteristics of the students along with the relevant variables. The second part provides the total number of statements, categorized according to their respective topics and variables. The third part presents the analysis of these statements in relation to the identified variables.

Data were collected using a simple random sampling technique. The geographical scope of the study was District Layyah, including its respective tehsils. Information was gathered through closed-ended questionnaires administered online via Google Forms. A total of 250 teachers were selected as the target population for the study. The sample comprised male and female teachers from public sector institutions in District Layyah.

Table 1

Objective 1: Level of Awareness Regarding STEM-Based Education (N = 250)

S. No	Statement	Agree %	Neutral %	Disagree %	Mean	SD
1	STEM education is a systematic way of learning.	78%	12%	10%	3.98	0.88
2	STEM provides clear information about student learning outcomes.	74%	14%	12%	3.85	0.92
3	STEM provides clear information about content.	72%	15%	13%	3.79	0.95
4	STEM improves problem-solving skills.	84%	8%	8%	4.15	0.81
5	STEM improves creative skills.	82%	9%	9%	4.08	0.85
6	STEM increases students' interest in the course.	76%	13%	11%	3.92	0.90
7	STEM improves perception of science.	80%	10%	10%	4.02	0.86
8	STEM improves perception of technology.	83%	9%	8%	4.10	0.82
9	STEM improves perception of engineering.	79%	12%	9%	3.99	0.87
10	STEM improves perception of mathematics.	77%	13%	10%	3.94	0.89
11	STEM encourages interesting learning.	85%	7%	8%	4.18	0.78
12	STEM ensures comprehension through fun.	81%	10%	9%	4.05	0.84
13	STEM increases academic achievement.	75%	14%	11%	3.88	0.91
14	STEM develops interdisciplinary interaction.	83%	9%	8%	4.12	0.80
15	Seminars/workshops for STEM awareness are necessary.	88%	6%	6%	4.28	0.72
Overall				4.330.96		



The findings in Table 1 indicate a high level of conceptual awareness of STEM education among secondary school teachers. The overall mean score (M = 4.03, SD = 0.86) reflects strong agreement with statements describing the nature, benefits, and instructional value of STEM education. A substantial majority of respondents (ranging from 72% to 88%) agreed that STEM education is systematic, interdisciplinary, and enhances learning outcomes.

The highest mean scores were observed for statements such as "Seminars/workshops for STEM awareness are necessary" (M = 4.28) and "STEM encourages interesting learning" (M = 4.18). This suggests that teachers not only understand STEM as a structured pedagogical approach but also perceive it as engaging and motivational for students. These findings are consistent with the argument that integrated STEM instruction enhances student engagement, creativity, and higher-order thinking skills (Honey et al., 2014).

Furthermore, high agreement regarding STEM's role in improving problem-solving skills (M = 4.15) and interdisciplinary interaction (M = 4.12) reflects teachers' awareness of STEM's emphasis on real-world problem solving and subject integration. According to Bybee (2013), STEM education is designed to prepare learners for complex, interdisciplinary challenges, which aligns with the perceptions shown in this dataset.

The relatively low standard deviations across items indicate consistency in responses, suggesting shared understanding among teachers. Overall, Table 1 demonstrates that secondary school teachers possess a strong theoretical understanding of STEM education and its educational value. This fulfills Objective 1, confirming a high level of awareness.

Table 2

Objective 2: Challenges in Implementing STEM Education (N = 250)

S. No	Statement	Agree %	Neutral %	Disagree %	Mean	SD
1	Teachers lack guidance in STEM.	68%	14%	18%	3.64	1.02
2	STEM professionals share knowledge about STEM.	52%	20%	28%	3.28	1.08
3	STEM integrates science with other subjects.	70%	15%	15%	3.71	0.96
4	Teachers are aware of STEM teaching methods.	60%	18%	22%	3.46	1.04

S. No	Statement	Agree %	Neutral %	Disagree %	Mean	SD
5	Teachers manage STEM resources effectively.	55%	19%	26%	3.34	1.07
6	STEM promotes knowledge sharing.	73%	12%	15%	3.79	0.93
7	Better equipped laboratories are needed.	86%	7%	7%	4.21	0.79
8	Lack of time hinders STEM activities.	82%	8%	10%	4.05	0.88
9	STEM requires more time than traditional teaching.	78%	10%	12%	3.94	0.91
10	Using STEM activities is challenging in classrooms.	74%	11%	15%	3.82	0.95
11	STEM requires inclusion of multiple activities.	80%	9%	11%	4.01	0.89
12	Teachers have unclear directions for STEM activities.	69%	13%	18%	3.67	1.00
Overall					**0.963.74**	

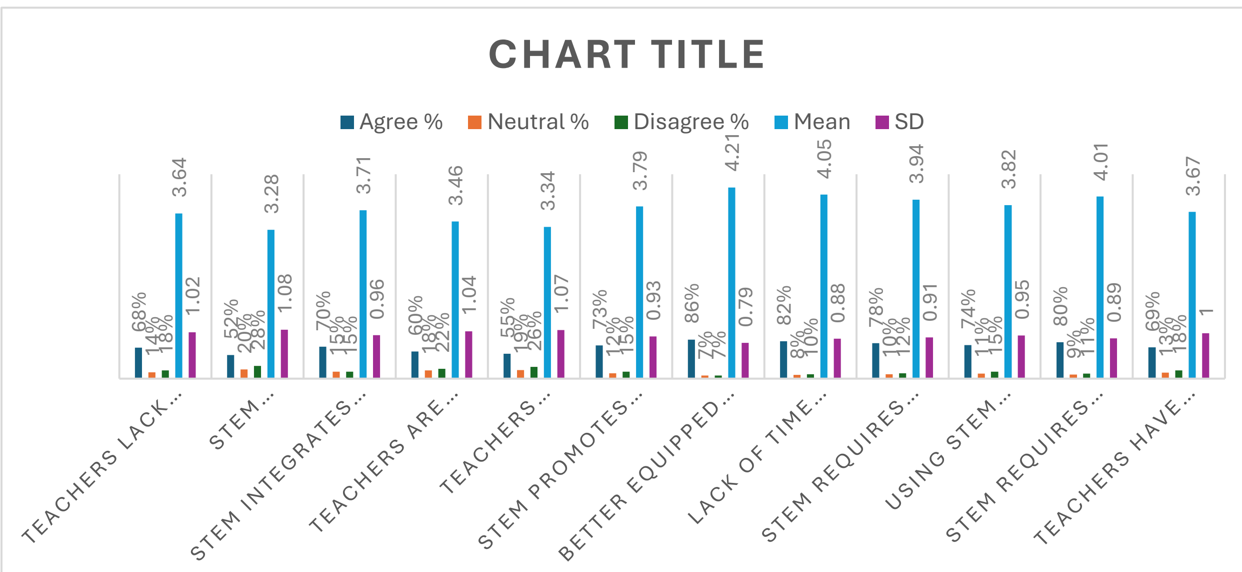


Table 2 presents teachers' perceptions of practical and structural challenges in implementing STEM education. The overall mean (M = 3.74, SD = 0.96) indicates moderate to high agreement with statements identifying barriers.

A significant proportion of teachers reported lack of time (82%, M = 4.05) and the need for better equipped laboratories (86%, M = 4.21) as major constraints. These high means reflect infrastructural and logistical challenges that commonly hinder STEM implementation. Research indicates that effective STEM teaching requires access to materials, laboratory facilities, and collaborative learning environments (Thibaut et al., 2018).

Additionally, teachers acknowledged unclear directions (M = 3.67) and lack of guidance (M = 3.64), suggesting gaps in professional support systems. Although teachers are conceptually aware of STEM principles (as shown in Table 1), they may lack sufficient pedagogical training to execute STEM-based activities effectively. Wang et al. (2011) emphasize that teacher preparedness and institutional support are critical determinants of successful STEM integration.

The mean values for "STEM requires more time than traditional teaching" (M = 3.94) and "Using STEM activities is challenging in classrooms" (M = 3.82) further reinforce that implementation demands additional planning, coordination, and classroom management skills.
Overall, Table 2 reveals that while teachers recognize the value of STEM education, practical challenges—especially time constraints, insufficient resources, and limited guidance—significantly affect its effective implementation. This finding directly addresses Objective 2.

Table 3
Objective 3: Institutional Support and Awareness–Practice Relationship (N = 250)

S. No	Statement	Agree %	Neutral %	Disagree %	Mean	SD
1	More classroom space is needed for group activities.	81%	8%	11%	4.02	0.90
2	Teachers need expertise in integrating STEM subjects.	85%	7%	8%	4.17	0.80
3	Lack of government investment in STEM.	76%	11%	13%	3.90	0.93
4	Teachers face lack of STEM resources.	79%	9%	12%	3.98	0.89
5	Government efforts to promote STEM in Pakistan are unsatisfactory.	72%	14%	14%	3.83	0.97
6	Lack of in-service training opportunities.	84%	7%	9%	4.13	0.85
7	Financial benefits are provided for STEM projects.	38%	21%	41%	2.96	1.15
Overall					**0.933.86**	

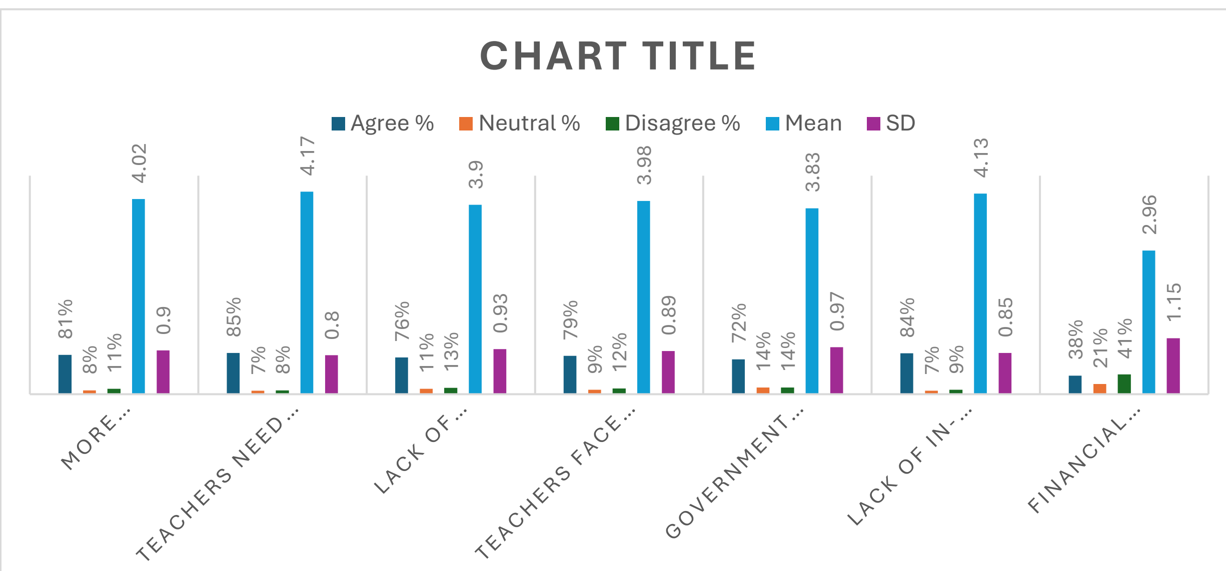


Table 3 examines institutional support factors influencing STEM practice and the relationship between awareness and implementation. The overall mean (M = 3.86, SD = 0.93) indicates strong agreement that systemic and institutional factors influence the application of STEM education.
High agreement was found for statements such as "Teachers need expertise in integrating STEM subjects" (85%, M = 4.17) and "Lack of in-service training opportunities" (84%, M = 4.13). These results suggest that although teachers understand STEM conceptually, professional development

remains insufficient for effective classroom practice. According to Honey et al. (2014), teacher capacity building through sustained professional development is essential for successful STEM reform.

Similarly, a majority of respondents agreed that government investment and policy efforts are inadequate (M = 3.90; M = 3.83). The low mean for financial incentives (M = 2.96) indicates dissatisfaction regarding monetary or motivational support for STEM projects. This reflects broader concerns about policy-level facilitation and institutional backing.

The need for more classroom space (M = 4.02) and adequate resources (M = 3.98) further indicates that environmental and infrastructural factors directly affect teachers' ability to translate awareness into practice.

Taken together, the findings suggest a positive relationship between conceptual awareness and perceived importance of STEM, but implementation is moderated by institutional constraints. Teachers demonstrate readiness and understanding; however, effective use depends heavily on systemic support mechanisms. This fulfills Objective 3 by highlighting how awareness alone is insufficient without adequate resources, training, and policy support.

Discussion

The study was conducted to explore factors influencing teachers' academic performance, particularly focusing on teachers' conceptual awareness of STEM education practices at the secondary school level. The findings reveal that teachers' conceptual awareness has a positive impact on their teaching performance. Respondents generally agreed that STEM education practices help update teachers' knowledge and improve instructional quality.

The results suggest that STEM education encourages continuous professional growth. Many teachers acknowledged that professional learning often declines after securing employment; however, STEM practices require ongoing engagement with new knowledge, technologies, and interdisciplinary approaches. This aligns with research by the National Research Council (2014), which emphasizes that effective STEM implementation depends on sustained professional development and teacher learning.

However, the study also identified certain challenges. Some respondents reported limited awareness of STEM education and expressed resistance due to insufficient resources and time constraints. A few participants perceived STEM initiatives as costly or impractical without adequate institutional support. These findings are consistent with earlier research highlighting barriers such as lack of infrastructure, insufficient training, and heavy workloads (Bybee, 2010).

Several respondents recommended structured internship programs before entering the profession and continuous knowledge-sharing activities after employment. This reflects the importance of professional development programs in strengthening teachers' conceptual understanding and practical implementation of STEM education.

Conclusion

Based on the analysis of the data, the following conclusions were drawn:

- The overall mean value of 3.18 and standard deviation of 0.98 indicate that respondents generally hold positive perceptions regarding strategies related to the use of STEM education practices.
- STEM education practices were perceived as beneficial for teachers' professional growth and knowledge updating in response to global educational and technological advancements.

- Participants acknowledged that teachers may encounter difficulties when students ask complex or interdisciplinary questions beyond their immediate expertise, highlighting the need for continuous professional learning.
- The overall mean value of 3.15 further supports that respondents demonstrated a favorable perception of STEM education practices.
- Although the descriptive analysis (mean value 3.14) indicates generally positive attitudes, some respondents considered STEM practices time-consuming or costly. A major contributing factor to negative perceptions was limited information or insufficient understanding of STEM education concepts.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

- Conduct further research on the effectiveness of integrating STEM education practices into the secondary school curriculum from the perspective of teachers' conceptual awareness.
- Investigate teachers' perceptions and knowledge of STEM education through detailed case studies at the secondary school level.
- Analyze the gap between teachers' understanding of STEM concepts and their practical classroom implementation.
- Develop targeted professional development programs aimed at enhancing teachers' preparedness and conceptual awareness of STEM education.
- Examine the influence of structured professional development initiatives on teachers' understanding and application of STEM practices.
- Conduct comparative studies to assess differences in teachers' conceptual awareness across various secondary school settings (rural vs. urban, public vs. private).
- Identify key factors affecting teachers' utilization of STEM practices, including institutional support, infrastructure, and training opportunities.
- Measure the impact of teachers' conceptual awareness on student outcomes and overall effectiveness of STEM integration.
- Explore pedagogical strategies that demonstrate how teachers' conceptual awareness shapes the implementation of STEM education.
- Investigate teachers' attitudes and perceptions toward STEM education and analyze their implications for policy and curriculum reform.

Refrences

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