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The Current State of STEM Education at Public Sector Secondary Schools in Quetta and Its Impact on Students' Learning Outcomes

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ABSTRACT

Aim of the Study: The current quantitative study was based on the insights of secondary school science subject teachers in Quetta, a city in Balochistan, Pakistan, to assess the current state of STEM education in the secondary schools in Quetta and its impact on students' learning outcomes.

Methodology: This quantitative study examine the relationship between the current state of STEM education, and institutional support for students' engagement and motivation in STEM education, moderating effect of students' learning outcomes. Through stratified random sampling, 63 boys' secondary schools and 59 girls' secondary schools were selected. Using simple random sampling, 300 science teachers (140 female and 160 male teachers) were selected. The data were collected through the Science Technology Engineering and Mathematics Questionnaire (STEM-Q), a self-developed tool.

Findings: The findings revealed that STEM education in the Public secondary schools of Quetta is not satisfactory. There is insufficient school support to enhance students' engagement and motivation for STEM education. Regression coefficient indicates, for every one-unit increase in the current state of STEM education, learning outcomes increase by 0.356 units. Similarly, a significant positive relationship was found between the current state of STEM education in schools and institutional support on students' engagement and motivation for STEM education, where approximately 15.2% of the variance in institutional support on students' engagement and motivation was explained by the current state of STEM education.

Conclusion: The current study determines that STEM activities and learning outcomes should be incorporated across all educational levels, and students can be educated for 21st-century skills, particularly in problem-solving skills. The teachers need to integrate hands-on project-based learning experiences to involve students in learning. Schools need to provide sufficient resources and funding to support STEM education initiatives and infrastructure development.

Keywords: STEM Education, Secondary Level Education, Public Sector Schools, Students' Learning Outcomes.

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1 INTRODUCTION

STEM, acronym for ‘Science, Technology, Engineering, and Mathematics’, education provides several significant benefits at the individual, societal, and global levels. At the individual level, the benefits are innovation, entrepreneurship, and economic growth, leading to job creation (Hynes et al., 2023) and increased prosperity. STEM education also develops problem-solving skills, critical thinking, and analytical skills, which are vital components for success in various careers (Skrentny & Lewis, 2022). It fosters creativity, innovation, and entrepreneurship, enabling individuals to develop new ideas and solutions (Valls Pou et al., 2022), and opens the door to a wide range of career opportunities, including high-paying jobs in fields such as technology, engineering, and healthcare (Eroğlu & Bektaş, 2022). At the societal level, STEM education leads to advances in medical research, healthcare technology, and disease prevention, improving overall health and well-being. It also addresses environmental challenges such as conservation, sustainable resource management, and climate change and encourages collaboration, teamwork, and communication, essential skills for success in various fields. At the global level, STEM education helps address pressing global challenges, such as poverty, inequality, and climate change, helping individuals and nations compete in the global economy, where technology and innovation are key drivers of success. It also supports healthcare technology and disease prevention. By emphasizing STEM education, individuals, communities, and nations can reap numerous benefits, driving innovation, economic growth, and societal progress.

Despite the rising significance of STEM education in Pakistan, literature reviews are scarce on STEM education, with most investigations being descriptive and only a small number intervention-based, such as Aslam et al. (2022), Ahmad (2018), and Ashraf (2016). To promote research activities in Pakistan, especially focusing on STEM education, it is imperative to understand the challenges in implementing STEM education at various levels of education. In addition, no studies have been conducted on the STEM education related to institutional support for students’ engagement and motivation and students’ learning outcomes. This study aims to assess the current state of STEM education in enhancing students' learning outcomes in secondary schools in Quetta.

The current study will inform workforce development initiatives, promote collaboration among educational institutions and industry, and foster innovation by helping educators develop career-ready students, equipped with the skills and knowledge required for success in the workforce.

1.1 Research Objectives

The current study was based on the following objectives;

1. To assess the current state of STEM education in the secondary schools in Quetta.
2. To investigate the institutional support influencing students' engagement and motivation towards STEM education.
3. To investigate the current state of STEM education that impacts students’ learning outcomes.
4. To explore the relationship between the current state of STEM education in schools and institutional support on students' engagement and motivation for STEM education.

2. REVIEW OF RELATED LITERATURE

In recent years, STEM education has garnered significant global interest. As evident from the literature review, the number of studies has consistently increased regarding STEM education (Chine & Larwin, 2022; Kelley & Knowles, 2016; Marco-Bujosa, 2021; Reynders et al., 2020; Turner et al., 2022; Wang et al., 2022; Yalçın, 2022). The STEM education is increasingly globalized, with nations like Pakistan in the Commonwealth following similar patterns to those in the United Kingdom. At the same time, European and Asian countries seem to be adopting the growth observed in the United States, as highlighted by Freeman et al. (2019). STEM education is gaining importance both as a subject and as a pedagogical approach (Tytler, 2020; Perales & Aróstegui, 2024) because, in this new interactive era, STEAM education is expected to transform the direction of education (Tan, 2020). On the other hand, Tesconi and De Aymerich Vadillo (2020) mentioned that STEAM education is an approach that supports the development of scientific and technological capabilities and skills essential to face global challenges and will be vital for the future workforce. An estimated 97 million new jobs are expected to be created worldwide by 2025 (World Economic Forum, 2020). "In Pakistan, the Ministry of Information Technology and Telecommunications (2020), in collaboration with Google, is initiating Pakistan's first grassroots-level Coding Skill Development Program for students aged 9 to 14 years" (Abbas et al., 2023, p. 466).

In the current study, the Self-Determination Theory has provided a guideline to examine how students' autonomy, competence, and relatedness affect their motivation and engagement in STEM education. STEM has recently been incorporated into education, and while many of its components, such as experiential learning, inquiry-based learning, decision-making, problem-solving, and social engagement, form its core, they also apply to other teaching methods.

To provide a comprehensive definition of STEM education, it is necessary to go beyond defining a single term and examine the goals and behaviors associated with STEM education. An acknowledged primary objective of STEM education is for students to develop a set of STEM literacy skills (English, 2016; Leung, 2020). STEM literacy encompasses "a range of abilities such as research inquiry, problem-solving, critical and creative thinking, entrepreneurship, collaboration, teamwork, and communication" (Falloon et al., 2020, p. 369). Typically, STEM education methods widely acknowledge the need to incorporate a specific problem for resolution (Kloser et al., 2018). The problem may have a high degree of specificity to a particular subject or may be positioned within a context that is meaningful to the student. Similarly, scientific investigation aimed at finding solutions to these issues is another crucial component of STEM education, as mentioned in different studies (Aslam et al., 2022; Holmlund et al., 2018; Punzalan, 2022). As mentioned by Sanders (2009, p 21), "STEM education is teaching and learning two or more STEM subject areas, or teaching one STEM subject integrated with other school subjects". STEM education is gaining importance to prepare future generations to adapt to the rapid changes that are coming in their lives, as highlighted by Bardoe et al. (2023). STEM education provides conceptual knowledge and stimulates critical and creative thinking skills (Yalçın, 2022).

In the modern era, STEM education serves as a tool to solve complex problems through innovation, as emphasized by He et al. (2023). Implementing STEM education in Pakistan aims to cultivate a workforce equipped with the skills to effectively combine practical experience and academic knowledge from various fields to address real-world challenges in the 21st century. The youth population is increasing in Pakistan (64% of the country's population is under 30), and it is expected to continue to grow until at least 2050 with a workforce of approximately 4 million each year (Aslam et al., 2022). So, creating about 1.3 million new jobs yearly is necessary to increase labor force participation rates, as mentioned by Ahmad (2018). However, Ashraf and Hafiz (2016, p.650) stated that "Ideally, graduates should be able to earn a living to support themselves and the general welfare of the community". To promote a competent workforce in Pakistan, STEM education is crucial to fully understand existing theories of teaching and the practices of teaching (Falloon et al., 2020; Hack, 2017; Marco-Bujosa, 2021).

With the advancement and growth in STEM education, it is imperative to motivate students through their active involvement, interests, and accomplishments in STEM education (Bardoe et al., 2023; Tohani & Aulia, 2022; Van den Hurk et al., 2019; Wannapiroon & Pimdee, 2022). According to Kennedy et al. (2021), high-quality STEM education needs demanding curriculum, assessment, and instruction. Thus, the curriculum needs to be redesigned and restructured to improve skills related to STEM education so that technology and engineering can be integrated into the curriculum of science and mathematics, which can enhance scientific inquiry (Katsioloudis & Moye, 2015; Khan et al., 2024). Furthermore, efficient instruction in STEM and supporting education stakeholders to inspire and encourage students in STEM subjects are some measures taken by various countries (Liu et al., 2022; Mendick et al., 2017; Ou et al., 2021).

Developing countries are also taking action to inculcate skills through education so that students can face new challenges like global warming, dangerous chemicals, environmental safety, and ensuring success to overcome the challenges faced by changing world conditions (Hasanah, 2020; Razi & Zhou, 2022). Therefore, schools can play an important role in students' motivation for STEM education by providing a conducive learning environment. Besides the factors mentioned above, many other areas need to be considered to motivate and engage students for STEM education. Classroom size and environment, grouping of students, class schedule, teachers' interactions with students, classroom quizzes and assignments, co-curricular activities, school climate, students' relationship with peers, teachers and school administrators, and staff are some of the factors that can play a crucial role in student motivation towards learning (Vennix et al., 2018; Wannapiroon & Pimdee, 2022).

3. RESEARCH METHODOLOGY

This quantitative study used a descriptive and correlational method to examine the relationships between the independent variable, the current state of STEM education, and the dependent variables, namely institutional support for students' engagement and motivation, with students' learning outcomes as the moderating variable. The population of secondary schools in Quetta is 148, including 72 girls' secondary schools and 76 boys' secondary schools. The total population of secondary school science subject teachers is 643, including 355 male teachers in Boys' schools and 288 female teachers in Girls' schools. Through stratified random sampling, 63 boys' secondary schools and 59 girls' secondary schools were selected, and 300 science teachers, including 140 female teachers and 160 male teachers, were selected through a simple random sampling. The Science Technology Engineering and Mathematics Questionnaire (STEM-Q) was used, a self-designed questionnaire based on the review of the literature and the opinions of professionals in the field of education. The tool reliability was measured through Cronbach's alpha after pilot testing, indicating high reliability (.983). The data were collected from secondary school science teachers, and the questionnaire was completed on-site, and the hard copies of the completed responses were immediately collected from the respondents. Using SPSS software, data analysis was conducted using descriptive statistics such as percentages, means, frequencies, and standard deviations, and inferential statistical methods including regression analysis.

4. FINDINGS

The study's findings were based on 4 objectives with two hypotheses. For the research objective number 1, an eight-item questionnaire was adopted that explores the current state of STEM education in secondary schools of Quetta, as indicated in Table 1.

Research Question 1: What is the current state of STEM education in the secondary schools in Quetta?

Table 1 represents the descriptive statistics of the current state of STEM education in secondary schools in Quetta. The majority of the participants (57.63%) disagreed with the statements, among them 54.92% disagreed and 2.71% strongly disagreed. However, 37.79% agreed with the statements, indicating that the current state of STEM is satisfactory, with 35.33% agreeing and 2.46% strongly agreeing., Meanwhile, 4.58% of the participants neither disagreed nor agreed with the statements. The overall mean score was observed regarding the current state of STEM education in secondary schools ($M = 2.8$, $SD = .98$). Among the statements, the highest mean score was observed for the item 8, stating 'my school organizes STEM-related competitions or events for students' ($M = 2.92$, $SD = 1.020$). However, the lowest mean score was recorded for item 1, stating, 'my school adequately integrates STEM subjects into the curriculum' ($M = 2.7$, $SD = 1.004$).

Table 1: *Descriptive Statistics of the Current State of STEM Education*

Questions	SD	D	N	A	SA	M	SD
1. My school adequately integrates STEM subjects into the curriculum.	07 (2.3%)	183 (61%)	10 (3.3%)	94 (31.3%)	06 (02%)	2.70	1.004
2. In my school, students show a strong interest in STEM-related activities and projects.	06 (02%)	169 (56.3%)	17 (5.7%)	100 (33.3%)	08 (02.7%)	2.78	1.020
3. In my school, professional development opportunities for STEM educators are sufficient.	10 (3.3%)	168 (56%)	08 (2.7%)	105 (35%)	09 (03%)	2.78	1.058
4. In my school, the provision and availability of STEM resources such as labs, equipment, and materials are adequate.	08 (2.7%)	163 (54.3%)	21 (7%)	103 (34.3%)	05 (1.7%)	2.78	1.007
5. In my school, STEM teachers collaborate with other subject teachers to encourage STEM learning.	05 (1.7%)	167 (55.7%)	15 (5%)	106 (35.3%)	07 (2.3%)	2.81	1.019
6. My school facilitates the provision of co-curricular STEM programs for students.	19 (6.3%)	158 (52.7%)	10 (3.3%)	105 (35%)	08 (2.7%)	2.75	1.085
7. My school has partnerships with STEM industry professionals for student engagement	08 (2.7%)	154 (51.3%)	15 (5%)	114 (38%)	09 (3%)	2.87	1.052
8. My school organizes STEM-related competitions or events for students.	02 (0.7%)	156 (52%)	14 (4.7%)	121 (40.3%)	07 (2.3%)	2.92	1.020
Total	65 (2.71%)	1318 (54.92%)	110 (4.58%)	848 (35.33%)	59 (2.46%)	2.80	.980

The factors that influence students' engagement and motivation by the institutional support towards STEM education were measured through 9 items, as indicated in Table 2.

Research Question 2: What are the factors influencing students' engagement and motivation by institutional support towards STEM education?

Table 2 reports the descriptive statistics of the factors influencing students' engagement and motivation by institutional support. Results reveal that the majority of the participants (56.81%) disagreed with the statements, where 47.35% disagreed and 9.46% strongly disagreed. However, 5.04% of the participants neither agreed nor disagreed with the statements. Though 38.15% of participants showed their agreement with these statements, among them 33.38% disagreed, and 4.77% strongly disagreed. The overall mean score observed for the factors influencing students' engagement and motivation was M = 2.737 (SD = 1.14). However, the highest mean score was observed for item 32, stating, 'My school develops a STEM resource center for each student's access.' (M = 2.79, SD = 1.104), and the lowest mean score was observed for item 25, stating, 'My school provides professional development opportunities for students focused on STEM' (M = 2.65, SD = 1.216).

Table 2: *Institutional Support Influencing Students' Engagement & Motivation*

	Questions	SD	D	N	A	SA	M	SD
1.	My school provides professional development opportunities for students focused on STEM.	49 (16.3%)	131 (43.7%)	08 (2.7%)	99 (33%)	13 (4.3%)	2.65	1.216
2.	Encouragement and motivation of students in the classroom influence STEM learning.	31 (10.3%)	146 (48.7%)	15 (5%)	98 (32.7%)	10 (3.3%)	2.70	1.129
3.	My school enhances students' collaboration with external STEM organizations.	27 (9%)	151 (50.3%)	14 (4.7%)	93 (31%)	15 (5%)	2.73	1.141
4.	In my school, STEM learning is promoted by community engagement outside the classroom.	21 (7%)	159 (53%)	09 (3%)	94 (31.3%)	17 (5.7%)	2.76	1.138
5.	The STEM curriculum at the secondary level provides STEM learning opportunities to students.	32 (10.7%)	139 (46.3%)	11 (3.7%)	108 (36%)	10 (3.3%)	2.75	1.151
6.	My school establishes mentorship programs for students interested in STEM fields.	17 (5.7%)	164 (54.7%)	10 (3.3%)	97 (32.3%)	12 (4%)	2.74	1.093
7.	My school implements peer-to-peer STEM learning initiatives among students.	29 (9.7%)	144 (48%)	18 (6%)	90 (30%)	19 (6.3%)	2.75	1.168
8.	My school develops a STEM resource center for each student's access.	17 (5.7%)	154 (51.3%)	21 (7%)	92 (30.7%)	16 (5.3%)	2.79	1.104
9.	My school offers incentives for teachers to develop innovative mindsets among students.	23 (7.7%)	143 (47.7%)	25 (8.3%)	97 (32.3%)	12 (4%)	2.77	1.104
Total		246 (9.46%)	1231 (47.35%)	131 (5.04%)	868 (33.38%)	124 (4.77%)	2.73	1.14

Research Question 3: How does the current state of STEM education impact student outcomes? Research Hypothesis (H1): The current state of STEM education significantly impacts students' learning outcomes.

Research Hypothesis (H_1): The current state of STEM education significantly impacts students' learning outcomes.

Research Hypothesis (H_0): The current state of STEM education does not significantly impact students' learning outcomes.

Table 3 highlights the model fit summary of the regression analysis between the current state of STEM education and students' learning outcomes. The results reveal that a moderate positive correlation (R =

.307) was found between the state of STEM education and students' learning outcomes, about 9.4% (R^2 = .094) of the variance in learning outcomes is explained by the current state of STEM education. Although adjusted R^2 indicates the number of predictors, it still shows a small effect. The result is statistically significant, F(1,298) = 31.050, *p* = .000, indicating that the current state of STEM education significantly predicts students' learning outcomes. The regression coefficient indicates, for every one-unit increase in the current state of STEM education, learning outcomes increase by 0.356 units, B = .356, t = 5.572, significant at *p* =.000.

Table 3: *Linear Regression: Current State of STEM Education and Students' Learning Outcomes (change statistics)*

Model[a]	R	R^2	Adjusted R^2	Std. Error of Estimate	R^2 Change	F Change	df1	df2	Sig. F Change
	.307[b]	.094	.091	1.082	.094	31.050	1	298	.000

ANOVA[a]	Sum of Squares	df	Mean Square	F	Sig.
Regression	36.332	1	36.332	31.050	.000[b]
Residual	348.689	298	1.170		
Total	385.020	299			

Coefficients[a]	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	1.810	.189		9.561	.000
Current	.356	.064	.307	5.572	.000

a. Dependent Variable: Learning Outcomes

b. Predictors: (Constant), Current State of STEM education

Research Question 4: Is there a relationship between the current state of STEM education in schools and institutional support on students' engagement and motivation for STEM education?

> *Research Hypothesis (H_2):* There is a significant positive relationship between the current state of STEM education in schools and institutional support on students' engagement and motivation for STEM education.
>
> *Null Hypothesis (H_0):* There is no significant positive relationship between the current state of STEM education in schools and institutional support on students' engagement and motivation for STEM education.

Table 4 highlights the regression analysis to predict the institutional support for students' engagement and motivation based on the current state of STEM education in secondary schools of Quetta. The regression model was statistically significant at the .05 level, indicating that the current state of STEM education significantly predicts institutional support on students' engagement and motivation, F (1, 298) = 53.402, p < .001. The result further suggests that approximately 15.2% of the variance in institutional support on students' engagement and motivation is explained by the current state of STEM education, as the coefficient of determination was observed to be .152.

Whereas a weak positive relationship was observed between both variables (Beta = .390), the t-test for the slope was also significant, t(298) = 7.308, p < .001, suggesting that the current state of STEM education is an important predictor of institutional support for students' engagement and motivation. Furthermore, the unstandardized coefficient (B) indicates that for each unit increase in the current state of STEM education in secondary schools, students' engagement and motivation are expected to increase by 0.432 units.

Table 4: *Regression Analysis between the Current State of STEM Education and Students' Engagement and Motivation*

Model Summary[a]	R	R^2	Adjusted R^2	Std. Error	R^2 Change	F	df1	df2	Sig. F Change
1	.390b	.152	.149	1.001	.152	53.402	1	298	.000
Coefficients[a]	**B**		**Std. Error**		**Standardized Coefficient Beta**		**t**		**Sig.**
(Constant)	1.529		.175				8.728		.000
Current State of STEM Education	.432		.059		.390		7.308		.000

a. Dependent Variable: Institutional Support on Students' Engagement and Motivation

b. Predictors: (Constant), Current State of STEM Education

5. DISCUSSION

The following section discusses major findings of the current research study.

Current State of STEM Education

The findings revealed that the current state of STEM education in the secondary schools of Quetta is not satisfactory. Eight indicators reflected the current state of STEM education in secondary schools of Quetta including; STEM subjects are adequately integrated, students show a strong interest in STEM-related activities, professional development opportunities for STEM educators are sufficient, adequate availability of STEM resources, e.g., labs, equipment, and materials, collaboration between STEM teachers and other subject teachers for STEM learning, the school facilitates the provision of co-curricular STEM programs for students, the school has partnerships with STEM industry professionals for student engagement, and the school organizes STEM-related competitions or events. The majority of participants showed their disagreement with all eight statements mentioned above, disagreeing or strongly disagreeing with each statement, indicating that the current state of STEM is not satisfactory. Further, the findings show that the majority of the respondents showed the highest disagreement with the statement 'my school organizes STEM-related competitions or events for students', and 'the professional development opportunities for STEM educators were sufficient'.

In STEM education, professional development of teachers enables access to resources and learning opportunities that are not accessible through traditional methods of professional development, as emphasized by Gerde et al. (2023). Online courses, webinars, and virtual workshops can be offered through flexible, accessible, and tailored professional development, as also highlighted by Wannapiroon and Pimdee (2022). Additionally, technology-based programs can assist in collaboration among educators, supporting them in sharing and shaping their best practices for their professional growth and development. Similar findings were observed by Dare et al. (2021), who mentioned that technology is very helpful for students in developing professional growth. Furthermore, it boosts their sense of professional identity and improves instructional practices, as mentioned by Atkins et al. (2020). The lack of professional development opportunities for STEM educators was also a big deficiency. This finding is supported by many scholars who concluded that due to a lack of STEM training opportunities for teachers, the students do not receive high-quality engineering education, and sufficient training for teachers is required to incorporate an innovative integrated STEM approach into teaching methods. (Benitti & Spolaôr, 2017; Bhatti & Hassan, 2024; Demir et al., 2021; Eroğlu & Bektaş, 2022; Razi & Zhou, 2022; Wang et al., 2022).

In light of the importance of STEM education throughout all stages of education, teachers who are ready for innovation can be educated by adding STEM-related lessons to the universities teacher training programs, as also emphasized by Eroğlu and Bektaş (2022) and Wang et al. (2022). Earlier studies have also indicated that existing training programs in Pakistan do not sufficiently equip prospective teachers, such as, Abbas (2019), Hali et al. (2021), Hammad (2020), Imaad et al. (2016), Khan et al. (2021), and Mustafa et al. (2022). Similarly, Kennedy et al. (2021) emphasized that educators need specialized training and continual professional development to effectively implement STEM education into their instructional practices. Therefore, “teacher education programs need to be robust and coherent to prepare effective science teachers” (Mustafa et al., 2022, p. 326). Nevertheless, teachers’ classroom practices in Pakistan had remained low. Effective use of instructional resources relies on teachers’ competencies for effective integration into their instructional strategies. To move beyond conventional teaching approaches, there is a need to build a strong science coaching potency, along with developing syllabi, strategies, and new ideas. This opportunity is enabled by teacher development that can shift teachers’ traditional beliefs toward constructivist pedagogies, assessment, and strong subject-mastery. However, such effective teacher progress and development rely on coherent and rigorous education programs, as highlighted by Mustafa et al. (2022).

In Pakistan and specifically in Quetta, the schools are teaching science, technology, engineering, and mathematics in isolation, and there is a need to develop integrated STEM curricula that emphasize an interdisciplinary connection among various subjects and further encourage students to apply their knowledge in real-world problem-solving. The present study also found a lack of school-industry partnerships to engage students with STEM-related activities.

Institutional Support Influencing Students' Engagement and Motivation

Results revealed that the majority of the participants showed their concern about insufficient school support to enhance students’ engagement and motivation for STEM education; however, a considerable number of participants expressed concerns over the support provided by the school to improve students’ engagement and motivation for STEM education. For STEM education, several factors can enhance students’ engagement and motivation, as students’ encouragement and motivation influence STEM learning. These include: provision of more professional development opportunities by schools for students to focus on STEM; students’ collaboration with external STEM organizations facilitated by schools; community engagement outside the classroom to promote STEM learning; STEM learning opportunities for their students through STEM curriculum in secondary schools; mentorship programs provided by schools for their students to take interest in STEM fields; implementation of peer-to-peer STEM learning initiatives among students by schools; developing a STEM resource center within the school for student access by schools; offering incentives by schools for their teachers to develop innovative mindsets among students; and, creating awareness among parents regarding the importance of participation and performance in STEM education for students. Literature also emphasized the need for organized curriculum (Reynders et al., 2020), the need to reform the curriculum by including STEM, iSTEM, STEAM domains, and pedagogical approaches in national/provincial curricula (Razi & Zhou, 2022), and the integration of robotics technology, nurturing creativity and reassuring active participation in the educational voyage (Lavigne et al., 2007) by generating excitement among students for STEM fields. Similarly, Mustafa et al. (2022) also found a substantial positive outcome of the classroom environment, teachers’ feedback, and motivation on students’ academic success.

In the context of Pakistan, research studies advocate mentoring for science teaching (Abbas et al., 2023; Hali et al., 2021; Khan et al., 2021) and to strengthen science and technology, there is a need to provide “sufficient resources, techniques, and equipment at the grassroots level, i.e., at the educational institutes’ settings” (Mustafa et al., 2022, p 327), and collaboration, mentoring, and exposure to innovative teaching practices is required to enhance STEM educators' effectiveness (Imaad et al., 2016).

Results reveal that the majority of the participants expressed concern about the lack of school support to enhance students’ engagement and motivation for STEM education; however, a considerable number of participants agreed on the support provided by the school to improve students’ engagement and motivation for STEM education. Moreover, the majority of the participants revealed that there is a lack of

STEM resource centers to provide accessibility to students. By a considerable number of participants, it was also highlighted that there is a lack of promotion of STEM learning outside the classroom through community engagement. Studies showed that business collaborations and community participation have a key role in improving STEM learning experiences for students (Nash, 2017; Ou et al., 2021), and the community interaction outside the classroom is seen as beneficial to STEM learning (Debora & Pramono, 2021). Thus, the study reveals that the collaborations among various stakeholders provide students with excellent opportunities for mentoring, internships, and exposure to STEM jobs.

Students' Learning Outcomes

The majority of the participants disagreed with the statements about students' learning outcomes through STEM education, whereas a considerable number of participants reported improved learning outcomes through STEM education. Research papers have consistently shown that STEM education has a direct and positive impact on the quality of students' learning outcomes (Abdul-Rahaman & Tindam, 2024; Banilower et al., 2013). A literature review of 118 empirical studies by Sungur Gül (2023) showed a significant increase in the number of STEM studies over the past nine years, and the most reported benefit of STEM education helped students develop 21st-century skills. On the other hand, the most reported challenge was that STEM activities were difficult to design into the curriculum. In the current study, slightly more than half of the participants showed their disagreement with the statements about students' learning outcomes through STEM education. Whereas a considerable number of the participants reported that students' learning outcomes improve by STEM education through their agreement by stating that STEM education is effective in improving student problem-solving, critical thinking, creativity, innovation, collaboration, and teamwork skills. They also reported that it prepares them for future careers, for real-world applications and problems, increases students’ interest in science and math, and encourages students to pursue careers in science and technology. These results are in line with other studies, which concluded that STEM education prepares students for competition and to work in their fields (Banilower et al., 2013; Iliyasu & Etikan, 2021). Through STEM-based learning, students learn creativity, problem-solving, and reasoning (Khalid & Ahmed, 2019), and become innovators and inventors (Ah-Namand & Osman, 2018; Khan et al., 2024; Liu et al., 2022; Ortiz et al., 2018). Problem-based learning, in turn, leads to substantial performance improvements of students (Rifandi & Rahmi, 2019; Sungur Gül et al., 2023; Thibaut, 2018; Umar et al., 2023).

6. CONCLUSION

The study concluded that there is a significant impact of the current state of STEM education on students’ learning outcomes, and a significant positive relationship was found between the current state of STEM education in schools and institutional support for students' engagement and motivation for STEM education.

7. RECOMMENDATIONS

Based on the objectives and comprehensive analysis of the hypotheses, this study proposes the following key recommendations.

STEM activities and learning outcomes should be incorporated across all educational levels, and students can be educated for 21st-century skills, particularly in problem-solving skills. The teachers need to integrate hands-on project-based learning experiences to engage students and promote a deeper understanding of STEM concepts. Comparing various training models could reveal the best practices for preparing teachers to implement STEM education effectively. Students in Pakistan need to enhance their problem-solving skills, evidence-based practices, team collaboration, and critical thinking abilities, so they can compete with students from across the globe for employment and internships, as also recommended by Hali et al. (2021) and Teo et al. (2021).

The schools need to provide STEM infrastructure and investment in modern, well-equipped STEM facilities and resources to support hands-on learning experiences. The schools need to develop partnerships with industry to provide students with real-world learning experiences and career guidance. At the school level, instead of focusing on general literature, languages, and sociology, students should be taught a STEM-integrated curriculum. So they can perform well in various fields in the future, including science, technology, engineering, and math, as also recommended by Mustafa et al. (2022).

Parents need to encourage curiosity to foster a love for learning and exploration in their child, and there is a need to develop skills such as decision-making, critical thinking, problem-solving, and creativity. There is a need to develop clear STEM education standards and benchmarks to ensure consistency and quality across schools. Adequate resources and funding need to be allocated to support STEM education initiatives and infrastructure development. Furthermore, regular monitoring and evaluation are required to explore the efficacy of STEM education programs to inform policy decisions and drive improvement. Future studies can be conducted to explore the effect of particular STEM projects or activities on students' learning outcomes and investigate the lasting effects of STEM education on students' academic achievements and career decisions.

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