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The Intimacy of STEM Education among the Secondary School Teachers and Administrators of Public Sector Schools of District Quetta, Balochistan :An ambition in shaping the STEM Image in District Quetta

1. **Fayzan Malik**

fm6611.fm@gmail.com

M.Phil Education Research Scholar,
Institute of Education and Research,
University of Balochistan, Quetta..

2. **Dr. Zahida Abdullah**

zahidaabdullah2022@gmail.com

Lecturer, Institute of Education and
Research, University of Balochistan, Quetta.

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Fayzan Malik

M.Phil Education Research Scholar, Institute of Education and Research, University of Balochistan, Quetta.

Dr. Zahida Abdullah

Lecturer, Institute of Education and Research, University of Balochistan, Quetta.

Abstract

Over the past decade, there has been an intensified emphasis on STEM education to correspond with the goals of 21st-century education. This study was conducted to gauge the intimacy and existing status of STEM education among the public sector secondary school teachers and institutions of district Quetta. It also highlights the teaching strategies employed by these teachers and their cohesiveness with the strategies of STEM education for the feasible implementation of STEM, and it also helps in the development of intimacy among these teachers. In order to achieve the objectives, quantitative methodology was used. In Quetta there has 134 public secondary schools (81 for girls and 53 for boys) with a total teaching deployed staff of 737 (405 male and 332 female). By using stratified random sampling, 70 girls' schools and 48 boys' schools were selected. By considering Krejcie and Morgan Table, a sample of 248 was determined and uniformly distributed between male and female teachers. Data were collected through a self-developed questionnaire, and analyzed by using descriptive statistics (mean, standard deviation, frequencies and percentages). The results revealed that the intimacy of STEM education was generally low, and the existing status of STEM education was also not satisfactory. Furthermore, the teaching strategies employed by the teachers are not in line with the principles of STEM education. The study determines that the training programmes related to STEM should be incorporated in the teachers' trainings. Moreover, adequate laboratory facilities and availability of digital tools should be ensured for the successful transition from traditional methods of teaching to the market-advocated approaches.

Keywords: STEM Education, Public Sector Schools, Intimacy, Secondary School Teachers, Administrators.

Corresponding Author Email:

fm6611.fm@gmail.com

zahidaabdullah2022@gmail.com

I. Introduction

STEM-Education is an acronym for Science, Technology, Engineering and Mathematics education. It is an advanced learning technique that is diverting the attention of the instructors due to its nature of integrating all four major fields under the one umbrella. The aim of STEM education is to equip the learner with comprehensive knowledge of all four spheres, along with the enhancement of cognitive skills like problem-solving, critical thinking, innovation, and creativity, required for a deep understanding of this technologically orientated society. Most of the countries are integrating the concept of STEM in their education system for the development of interest of students through the miracles of technology, science, engineering and mathematics. Apart from this, they are also highlighting the teaching methods for STEM and the importance of teachers in the implementation of STEM education. For the feasible integration of STEM into the present structure of the education system, a revolution must be brought into the current traditional system of education. Moreover, it also exhibits the interdependency of all four domains involved in this system, identifying the global trends that will require the delivery of knowledge from these domains. The system of education that relies on the foundation of the STEM network brings a scenario which helps in the advancement of analytical approaches towards the situation, learning by doing, inventiveness, creativity, finding smart and swift solutions to the problem, and other similar traits, ultimately depicting the inclusive traits that are deceptive in the opportunities of STEM fields.

STEM education is essential for preparing students for the profession by providing them with the knowledge, skills, and mindset needed to thrive in today's quickly changing technology environment. This era is experiencing rapid advancements in mathematics, science, technology, and engineering, unlike any other period in human history.

STEM employment opportunities, integrating science, technology, engineering, and mathematics, are seeing rapid growth (American Association for the Advancement of Science, 2021; Ramaley et al., 2005; Scott-Parker & Barone-Nuget, 2019). The field of science expands our understanding, technology enables the application of scientific information, engineering involves constructing and innovatively using scientific information, and mathematics serves as the tool for investigating new ideas related to science (Scott-Parker & Barone-Nuget, 2019). During the period of 2010–2020, the real surge in mathematics and computer-oriented jobs was higher than the rise that was anticipated (Hira, 2022). Both Legislators and teachers work toward the common goal of preparing youngsters for careers in science, technology, engineering, and mathematics (STEM) in order to compete successfully in a digitally varied global economy. Jobs in future decades will need pupils to have strong numeracy and scientific literacy, but industries also value students who can think critically and creatively, qualities that computers and robots just can't replicate.

An enormous amount of Literature is present on STEM Education, as the developed countries are trying their best to divert the traditional system of education into the advanced one. Moreover, the research on STEM Education in Pakistan has not

in accordance with the pace of the changing world and the intimacy of the STEM Education in majority of the public sector educational institutions of various provinces and cities are not up to the mark and even the staff deployed there are not aware about the STEM Education. Subsequently, the unawareness with the modern and advanced methods of Education system, students are not prepared according to the demand of the job market and this is ultimately causing the socio-economic issues, unemployment, lack of capable work force, increase in crime rates, and other similar issue are being raised.

In accordance with the systematic literature review by (Sarfaraz Aslam et al., 2022), the trend of research on STEM education has resulted in a descendant trend in Pakistan. There is a dearth of literature review on STEM-Education in Pakistan, with most investigations being descriptive and only a small number being interventional. There is a declining trend in STEM-Education study in Pakistan, potentially caused by a lack of awareness amongst Pakistani scholars regarding the significance of STEM education. This lack of awareness has brought a substantial decline in the intimacy of the STEM-Education. In Pakistan, technology is the most extensively studied area in STEM-Education, with science and mathematics following closely behind. There is inadequate study on the engineering aspect.

In order to promote the STEM Education in Quetta, Balochistan and ultimately Pakistan, it is imperative to bring the intimacy of the STEM education among the individuals of the society especially the teachers at the public sector institutions of the district. A part from this, it is also important to understand the challenges for the implementation of the STEM education at various levels of Education. Moreover, no studies have been conducted so far on the STEM education intimacy and the effect of STEM education on the development of the cognitive skills of the students. This study aims to assess the intimacy of the STEM education among the secondary school teachers and administrators of the public sector schools of Quetta, Balochistan.

This study will bring intimacy about the STEM education in the district and help teachers of the public sector schools to engage students of their schools in line with the concept of STEM education. Moreover, it will also help in the development of workforce that is equipped with skills and knowledge required for the 21st century job market.

1.1 Research Objectives:

This study was based on the following objectives;

1. To check the intimacy and existing status of STEM education among the secondary school teachers of the public sector schools of District Quetta, Balochistan.
2. To explore the teaching and learning strategies used by the teachers of public sector schools that are in line with the STEM education for the effective implementation of STEM.

2. Review of Related Literature

STEM education is increasingly recognized around the world. This is true at all educational levels and pre-K–12 and tertiary institutions (Kennedy & Tunnicliffe, 2022; Takeuchi et al., 2020). Improving student proficiency in STEM studies at school level has become a global priority for students to be prepared for STEM jobs (Thibaut et al., 2018). In the United States, there is a growing emphasis on introducing STEM (science, technology, engineering and mathematics) in K–12, typically through inter-disciplinary or cohesive teaching (Kennedy & Odell, 2014), generally referred to “integrated STEM education” (Roehrig et al., 2021). Kelley and Knowles (2016, p. 3) said, “Teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context, enhances student learning”. Kennedy & Sundberg (2020) are of the observation that crucial parts of the 21st-century classroom. Individuals in many sectors have different interpretations of what STEM education is. This makes it hard to develop regulations, particularly with regard to developing effective STEM teaching methods that can help in achieving this goal (Leung, 2020). When a person tries to move from one knowledge field in STEM to another, a barrier is put up in their way that is hard to follow when looking at STEM pedagogies (Leung, 2020).

The science outreach programme has been in operation since 2013 in a total of nine schools in the cities of Lahore and Faisalabad. The research presents stem5, an initiative to rejuvenate STEM education in Pakistan. It includes outreach activities targeted at underprivileged students, such as a science outreach program and a summer coding camp. The initiative aims to influence the narrative for STEM education reform in the country. (Syed M. Imaad et al., 2016).

The Ministry for Planning, Development, and Reform of Pakistan organized a seminar and identified that the primary concern for public-school teachers is inadequate remuneration, which limits their ability to demonstrate their true potential and scientific competencies. However, despite the significant increase in teachers’ pay, public education has not significantly improved. This indicates that in addition to raising teachers’ pay, it is necessary to introduce educators who possess an innovative and sophisticated teaching methodology together with up-to-date academic knowledge. It is significant that the government has accepted the importance of science, technology, engineering, and mathematics education (Abbas et al., 2020). According to the goal, the government wants to promote the concept of STEM education in Pakistan by involving the Higher Education Commission and universities to introduce technology and innovative curriculum. Furthermore, the Higher Education Commission has promoted the STEM Career Initiative with the joint efforts of the Pakistan Institute of Engineering and Applied Science, which created the program to provide young people with an opportunity to get educated and find a job in any branch of science, technology, engineering, and mathematics. In addition to government authorities and institutes such as PIEAS, many commercial companies like Tech-Tree, STEM Innovative Foundations, STEM Pakistan, and others are also actively contributing to the advancement of STEM education in both the public and private sectors in Pakistan. Pakistan has taken various recent initiatives to

enhance the quality and access of education through STEM: Science, Technology, Engineering and Mathematics. One of the most notable instances is Usman Saifullah Khan and Dr Maria Rashid's Tech for Pakistan Private Limited Institute. The body aims for improved movement of skilled individuals in education to bring about fundamental and lasting change in the schooling system. By this initiative, they will attract and equip highly trained graduates, above all young professionals, to teach in low-cost schools which mean to offer quality education, but are still not capable to do so. Additionally, STEM Visions enterprise is also engaged in this viable activity of education and capacity-building. STEM Vision is one such remarkable project providing free of cost STEM education to underprivileged children all over Pakistan. It aims to make education more inclusive and attempts to narrow the educational gap between different socioeconomic groups.

STEM refers to Science, Technology, Engineering, and Mathematics. These subjects are important for innovation and national development and help establish critical thinking skills. Nowadays, STEM education has gained tremendous importance across the globe. The developed and developing nations are investing in programmes that merge these fields to equip learners for the future. Despite the fact that the United States model of STEM education has been adopted by a number of countries (Hali et al., 2020). Pakistan, as well as the UK and other commonwealth nations, is internationalizing a STEM framework for school kids in grades 7-12.

Moreover, we have witnessed these developments in countries in Europe and Asia too. While it is an ongoing trend around the world, there is little literature concerning STEM and science education in Pakistan. Previous studies have indicated that there have been more STEM initiatives in the private sector as compared to the public. While some Pakistani universities have made efforts to develop STEM programmes, there is little follow-through or coupling between universities. A coherent national approach to STEM education is complicated by this fragmentation. Nevertheless, the reflection of such initiatives is a positive sign of education empowerment in Pakistan. In collaboration with the degree-granting universities, private firms and regulators should create a framework to make teaching better so that the students become more creative, problem-solvers and innovators.

In Pakistan, there has been a decline in STEM education (Sarfraz Aslam et al., 2022). This means that not much research has been done on STEM education in Pakistan. According to the above study, majority of the research was descriptive in Pakistan while only four studies were international. There has been no research on STEM's engineering component. This starkly demonstrates the gap, warranting deeper investigation in Pakistan to enhance and embed STEM into the educational framework.

Pakistan has a staggering youth bulge, with 64% of our population being below the age of 30. Moreover, the ratio is not likely to decrease any time before 2050. And around 40 lakh people enter the labor market every year. If the present participation and unemployment rates continue in the next five years, only 0.9 million new jobs will be created every year. The country must create an extra 1.3 million jobs every year to keep pace with the increasing demand and participation of the workforce (Ahmad, 2018).

According to Ashraf & Hafiza (2016), the graduates need to have the necessary skills and competencies to earn a livelihood and serve society. It is as important to create an environment where youth can innovate, take risks and be productive as it is to maximize their potential. Policies designed to enhance education, create jobs, and increase civic engagement are important measures (Ahmad, 2018). It is vital to take into account the availability of STEM-based tertiary qualifications that adapt modern pedagogies to make our graduates employable in the future. Further, this will also give learners the knowledge of the changing global economy (Hack, 2017).

Prior literature evaluations have elucidated diverse factors pertaining to the STEM domain, predominantly from the US (Lee et al., 2019). While these reviews provide scholars with a framework, Pakistan limits its scope. Conducting comprehensive reviews of the status and advancements within certain disciplines is a standard technique in educational research (Li et al., 2020). STEM education and job path diversification are critical for the United States to maintain its position as a global leader in STEM (Coleman, 2020). Conducting more research to tailor STEM education to Asian countries' specific circumstances is equally critical (Lee et al., 2019). It is crucial to determine whether STEM education is a fundamental component of the answer (Wahono et al., 2020). Several Asian regions have gradually implemented and developed STEM education (Chen & Chang, 2018; Choi & Hong, 2015; Karahan et al., 2015; Park & Yoo, 2013). STEM/STEAM education is one of the most essential components in Korea, Thailand, China, and Malaysia concerning their educational systems (Cho, 2013; Hong, 2017; Hsiao et al., 2017; Kang et al., 2013; Shahali et al., 2017). Despite a broad-based consensus that stem education has been adopted by a large number of teachers and academics, its integration into educational systems in many Asian countries is not universal.

Various research and reports have shown that attention to Asia-based research on STEM education developments started in 2013 (Jayarajah et al., 2014; Lee et al., 2019). The ability to find published South and Central Asian STEM papers in English is a slow operation (Wahono et al. 2020). Therefore, the examination of the effects of STEM initiatives in Asia on Pakistan in the temporal period 2000–2020 becomes pivotal. With STEM education gaining popularity in Pakistan, there was no previous review covering this area. It is very important to have an understanding of the problem identified so that we can bring about change in the research efforts related to STEM-Education in Pakistan.

The Pakistan Science Foundation is the country's highest body, responsible for scientific and technological research advancement, financial support, and science promotion. The Pakistan Museum of Natural History and the Pakistan Scientific and Technological Information Centre, two associated organizations, comprise the Foundation.

PSF acts as a bridge between the PMNH and PASTIC agencies to set up integrated Scientific and Technological Information Dissemination Centers. It includes promoting research in universities and other institutions; developing science and technology centers and museums; granting recognition to scientific societies; organizing conferences; arranging exchange visits of scientists between countries; and distributing

awards and fellowships to individuals engaged in developing economically important processes for the country. The PSF's motto is to develop Pakistani manpower with scientific skills, enabling the country to meet global challenges in the 21st century.

The Pakistan Science Foundation, under the Ministry of Science and Technology, in pursuance of the government's vision to develop a knowledge economy, has started the "Launching of STEM in Pakistan, Phase-I" project. The government proposed that the federal and provincial stakeholders, along with the education department, would help in the overall roll-out of this national project. The project will assist in fast-tracking Pakistan's efforts to equip its population for the fifth Industrial Revolution.

The goal of the STEM Project 2022 is to establish 50 STEM labs in 50 higher secondary schools and cadet colleges across all provinces. The project has set up 50 laboratories in public-sector higher secondary schools across the country. Two of these laboratories are located in Quetta, Balochistan, with one designated for boys and the other for girls. Additionally, the project will construct eight labs at various universities and institutes. This initiative costs a total of 993.784 million rupees. Advanced technology such as 3D printers, vinyl cutters, design computers, and STEM kits will equip the labs. These tools will enable students to acquire essential skills and practices necessary for the 5th Industrial Revolution. The PSDP-approved project aims to enhance the educational abilities of both teachers and students throughout Pakistan. Unfortunately, the labs that are established in two public sector schools of Quetta are completely non-functional due to the unavailability of STEM professionals, teacher training programs, lack of qualified STEM specialists, proper management of STEM labs, inadequate funding for maintenance, integration of STEM aspect in curriculum, and the absence of hands-on learning / project-based learning environment. Consequently, the only entity is schools, that play crucial role in the integration of STEM education in the public sector institutions by motivating students towards experimental learning and developing their interest in learning by doing. Apart from the above there are other numerous things that needs to be considered for the successful integration of the STEM education these are; environment and size of classrooms, peer learning, student-teacher interaction, assignments and quizzes, co-curricular activities, school climate, relationship with peers, teachers, staff, and school administrators, these are the various factors that can bond a positive relationship for the motivation of students towards STEM learning. (Vennix et al., 2018; Wannapiroon & Pimdee, 2022).

3. Research Methodology

In this study, a quantitative research design was used; as a quantitative study, it used descriptive statistics to observe the relationship among variables. Quantitative research is a type of research in which the researcher examines the relationship among the different variables and measures them using the statistical approach for collection and analysis of data.

To explore the teaching strategy being used, and intimacy of STEM education in public sector secondary schools of Quetta, stratified random sampling was utilized. For this purpose, the population were divided into distinct subgroups (strata) such as girls'

and boys' secondary schools, and female and male science subject teachers from selected strata schools. This stratified sampling method allows researchers to obtain more accurate and generalizable results and ensures that each subgroup is proportionally represented while reducing bias, as highlighted by Ilyasu and Etikan (2021). Thus, this sampling method ensures that differences across gender and school type are captured spontaneously, which is essential for evaluating the overall results obtained.

Therefore, the population was divided into distinct strata based on natural groupings through stratified random sampling: boys' secondary schools (53) and girls' secondary schools (81), as well as female (332) and male (405) science subject teachers from these schools. By using the Krejcie and Morgan Table (1970), sample sizes were determined, which included 48 boys' secondary schools and 70 girls' secondary schools that were randomly selected from their respective groups. For selecting teachers from the population size of 737, a total sample size of 248 was determined as per the Krejcie and Morgan Table, which was then proportionally allocated between male and female teachers. Therefore, the sample size was rounded to 250 samples of secondary school science subject teachers to improve the accuracy and reduce the margin of error. Then, from 250 samples of science teachers (strata of male and female science teachers), the simple random sampling method was applied to select the participants, ensuring fair and proportional representation across all subgroups. This sampling method helped to minimize sampling bias and improve the accuracy and generalizability of the study's findings. Table 1 highlights the sample size determined for schools and secondary school science subject teachers with the help of the Krejcie and Morgan Table (1970).

Table 1

Sample Size Determination Using Krejcie and Morgan Table

	N	Sample Size as per Krejcie & Morgan Table
Schools	134	119
Boys school	53	48
Girls' schools	81	70
Secondary School	737	248
Teachers		
Female	332	
Male	405	

Additionally, for the collection of responses a self-developed STEM questionnaire was used. This questionnaire is based on the literature review and also includes the suggestions by the experts in the field of education. For determining the reliability of the tool, Cronbach's alpha was used, after the pilot testing of the Questionnaire. The value of the reliability was obtained is 0.882, which is high enough to say that the tool used is reliable. The data were collected from public sector secondary school science teachers and the questionnaire was complete on-site, the hard copies are collected immediately

from the respondents, and also through the disbursement of Google forms questionnaires via various platforms.

The questionnaire consisted of two parts: part 1 had questions related to the intimacy and existing status of the STEM education, while part 2 had questions related to the teaching and learning strategies used by the teachers of public sector schools. The intimacy and existing status were presented through 12 items, while the teaching and learning strategies were also measured by 12 items. The scale was a five-point Likert Scale ranging from strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree for the first part and never, rarely, sometimes, often, and always for the second part of the questionnaire. The data analysis was conducted by using SPSS (version 21) and the descriptive statistics such as frequencies, mean, standard deviation and percentages, of the data obtained were calculated.

4. Findings

The findings of the study are represented in the following tables in line with the objectives of the study. For the first objective a twelve item self-developed questionnaire was conveyed that determines the intimacy of the STEM Education among the secondary school teachers and existing status in public sector schools of district Quetta, as highlighted in Table 2. However, for the second objective another twelve item self-developed questionnaire was adopted to check the existing status of the STEM Education in the public sector secondary level schools of district Quetta.

Research Question 1: What is the existing status in terms of intimacy, promotion, integration, understanding, implementation, experimentation, facilities, availability of tools, curriculum and training, of STEM education in the public sector schools of Quetta?

Table 2 represents the descriptive statistics of the intimacy of STEM among the secondary school teachers and existing status of the STEM Education in public sector secondary level schools of district Quetta. The majority of participants (51.33%) disagreed with the statements, among them 33% disagreed and 18.33% strongly disagreed. However, 42.33% agreed with the statements, indicating that they are aware about STEM Education and the existing status of STEM in their schools is satisfactory, with 29.4% agreeing and 12.93% strongly agreeing. Meanwhile, 6.33% of the participants neither disagreed nor agreed with the statements. The overall mean score was observed regarding the intimacy and existing status of STEM Education ($M= 2.87$, $SD= .602$). Among the statements, the highest mean score was observed for the item 5, stating 'Students are encouraged to take part in hands-on experiments and learning projects' ($M= 3.72$, $SD= 1.283$). However, the lowest mean was observed for the item 9, stating 'Digital tools (such as computers, multimedia, and internet) are available for teaching STEM subjects' ($M= 2.10$, $SD= 1.203$).

Table 2: Descriptive Statistics of the Intimacy and Existing Status of STEM Education

Statements	SD	D	N	A	SA	M	SD
1. I am familiar with the concept of STEM education.	41 (16.4%)	118 (47.2%)	9 (3.6%)	63 (25.2%)	19 (7.6%)	2.60	1.238
2. STEM education is actively promoted in my school.	44 (17.6%)	108 (43.2%)	20 (8.0%)	67 (26.8%)	11 (4.4%)	2.57	1.184
3. Teachers in my school have sufficient understanding of STEM principles.	61 (24.4%)	98 (39.2%)	17 (6.8%)	50 (20.0%)	24 (9.6%)	2.51	1.312
4. STEM education is effectively implemented in classroom teaching at my school.	37 (14.8%)	116 (46.4%)	17 (6.8%)	72 (28.8%)	8 (3.2%)	2.59	1.145
5. Students are encouraged to take part in hands-on experiments and learning projects.	24 (9.6%)	31 (12.4%)	12 (4.8%)	106 (42.4%)	77 (30.8%)	3.72	1.283
6. My teaching practices focus on problem solving and critical thinking skills.	42 (16.8%)	56 (22.4%)	11 (4.4%)	83 (33.2%)	58 (23.2%)	3.24	1.452
7. Group activities and collaborative learning methods are regularly used to promote STEM learning.	26 (10.4%)	41 (16.4%)	23 (9.2%)	104 (41.6%)	56 (23.2%)	3.49	1.287
8. My school has adequate laboratory facilities to support STEM-related activities.	33 (13.2%)	142 (56.8%)	13 (5.2%)	53 (21.2%)	9 (3.6%)	2.45	1.075
9. Digital tools (such as computers, multimedia, and internet) are available for teaching STEM subjects.	90 (36.0%)	109 (43.6%)	2 (0.8%)	34 (13.6%)	15 (6.0%)	2.10	1.203

The Intimacy of STEM Education among the Secondary School Teachers and Administrators of Public Sector Schools of District Quetta, Balochistan : An ambition in shaping the STEM Image in District Quetta

10. The school curriculum supports the integration of STEM education.	38 (15.2%)	41 (16.4%)	39 (15.6%)	84 (33.6%)	48 (19.2%)	3.38	1.078
11. Have you ever had any STEM training?	70 (28.0%)	105 (42.0%)	18 (7.2%)	52 (20.8%)	5 (2.0%)	2.27	1.139
12. Students in my school show motivation and interest in STEM-related subjects.	44 (17.6%)	25 (10.0%)	9 (3.6%)	114 (45.6%)	58 (23.2%)	3.58	1.132
Total	550 (18.33%)	990 (33.0%)	190 (6.33%)	882 (29.4%)	388 (12.93%)	2.87	0.602

It is evident from table 2 that the agreement level is low or disagree in critical statements related to the intimacy of STEM education. Item 1 enquires about the familiarity of the term 'STEM Education'; in this the level of agreement is low, which clearly reflects that the intimacy of STEM Education among the secondary school teachers of the public sector is not satisfactory. In addition, Item 3 is about the understanding of the principles of STEM Education; the agreement level in this query is also low, and the majority of the respondents show their disagreement with the statement. This depicts that the principles related to the effective teaching of STEM education are not known to the teachers of the public sector secondary schools. Furthermore, Item 11 is related to the acquisition of the STEM training. In this statement, the level of agreement is also low, and the majority of the participants show their disagreement that they had never received any training related to STEM Education. This replicates that the intimacy of STEM Education is very low due to the lack of training opportunities, even from the government perspective. Subsequently, Items 6 and 10 portray that the respondents are unable to make decisions in respect of the integration of curriculum and their teaching practices; thus, the level of agreement is moderate or neutral. The only high agreement is shown in item 5, among the total of six items related to intimacy, and that is the encouragement of students in hands-on experiments and learning projects, irrespective of the understanding of STEM education and also not knowing about the fact that this attribute is directly linked with one of the major aspects of STEM education. Teachers encourage students for their participation in hands-on learning; this is a good forecast about the feasible and effective implementation of STEM education if the efforts are paid towards the inclusion of the STEM education concept among the teachers of public sector schools.

Additionally, the level of agreement in terms of the existing status of STEM education in the public sector secondary-level schools of district Quetta, Among the total of six statements related to the existing status of STEM education, the majority reflect disagreement with the statements, and all those statements which reflect

disagreement are the most vital for the scrutiny of the existing status of STEM education. Item 2 asks about the active promotion of STEM education; the level of agreement from the participants is low or disagree, reflecting that STEM education is not pursued in their schools. In addition, the views of the respondents against item 4 also showed the level of agreement as 'low' or 'disagree'. Item 4 asked about the effective implementation of STEM education in schools; the low level of agreement highlights that STEM education is not effectively implemented in their schools. Moreover, the level of agreement with item 8 is also low or disagree; in item 8, the respondents were asked about the adequate laboratory facilities at their schools. The low level of agreement shows that the laboratory facilities at the public sector schools are not adequate in terms of the effective implementation of STEM education. Likewise, item 9 was related to the availability of digital tools; in this the level of agreement is also low or disagreeing, reflecting that the digital tools are not available at the public sector schools for teaching STEM-related subjects. The mean obtained for item 9 is the lowest among all the statements and showed the highest level of disagreement. Whereas, only items 7 and 12 showed the level of agreement as 'high' or 'agree'. Item 7 is about the usage of group activities and collaborative learning methods; the high level of agreement shows that the group activities and collaborative learning are promoted in the public sector schools, which is good enough for the effective implementation of STEM education. Item 12 is about the motivation and interest of students in STEM-related subjects. The high level of agreement shows that the students in public sector schools are motivated and have an interest in the STEM subjects. This is also a good sign for the attraction of students to the STEM-related fields.

Research Question 2: What is the teaching and learning strategies used by the teachers to enhance the methodology of STEM education in the public sector schools of Quetta?

Table 3 presents the descriptive statistics of the strategies used by teachers to enhance STEM education in secondary schools of Quetta. The majority of participants (27.67%) responded that they never used these strategies to enhance STEM education. Additionally, 25.57% of the participants sometimes utilized these strategies to enhance STEM education in their classroom, 23.46% of the participants always used them, 17.73% often used these strategies, and 5.55% of participants rarely used these strategies in their classroom. The overall mean score observed for the strategies employed by teachers in their teaching was 3.04 with a standard deviation of 1.439. Among these strategies, the highest mean score was observed for the strategy 'identifying similarities and differences', which was item 9 ($M = 3.39, SD = 1.267$). In contrast, the lowest score was observed for 'Home Work and Practice' which was item 17 ($M = 2.65, SD = 1.540$).

Table 3: Descriptive Statistics of the Strategies used by the Teachers

Statements		Never	Rarely	Sometimes	Often	Always	M	SD
1.	Problem Based Learning	82 (32.8%)	13 (5.2%)	68 (27.2%)	33 (13.2%)	54 (21.6%)	2.86	1.533
2.	Inquiry based Instructions	94 (37.6)	16 (6.4)	49 (19.6)	48 (19.2%)	43 (17.2%)	2.72	1.542
3.	Building Physical Models	50 (20%)	17 (6.8%)	78 (31.2%)	27 (10.8%)	78 (31.2%)	3.26	1.471
4.	Using Computer Simulations	37 (14.8%)	14 (5.6%)	73 (29.2%)	72 (28.8%)	54 (21.6%)	3.37	1.293
5.	Cooperative Learning	79 (31.6%)	8 (3.2%)	46 (18.4%)	51 (20.4%)	66 (26.4%)	3.07	1.601
6.	Students-Led Projects	80 (32%)	13 (5.2%)	70 (28.0%)	33 (13.2%)	54 (21.6%)	2.87	1.523
7.	Setting Objectives and Providing Feedback	94 (37.6%)	16 (6.4%)	52 (20.8)	45 (18.0%)	43 (17.2%)	2.71	1.536
8.	Identifying Similarities and Differences	34 (13.6%)	14 (5.6%)	76 (30.4%)	72 (28.8%)	54 (21.6%)	3.39	1.267
9.	Graphic Organizers	79 (31.6%)	8 (3.2%)	43 (17.2%)	54 (21.6%)	66 (26.4%)	3.08	1.604
10.	Videos and Images	80 (32%)	13 (5.2%)	73 (29.2%)	30 (12.0%)	54 (21.6%)	2.86	1.518
11.	Home Work and Practice	99 (39.6%)	16 (6.4%)	49 (19.6%)	45 (18%)	41 (16.4%)	2.65	1.540
12.	Writing a Scientific Argument	48 (19.2%)	17 (6.8%)	78 (31.2%)	29 (11.6%)	78 (31.2%)	3.29	1.458
Total		856 (28.53%)	165 (5.5%)	755 (25.16%)	539 (17.96%)	685 (22.83%)	3.01	1.444

5. Discussion

Intimacy and Existing Status of STEM Education

The findings revealed that the majority of the participants are unaware about the concept of STEM Education. A twelve item self-developed questionnaire reflected the intimacy and existing status of STEM Education including; I am familiar with the concept of STEM education, STEM education is actively promoted in my school, Teachers in my school have sufficient understanding of STEM principles, STEM education is effectively implemented in classroom teaching at my school, Students are encouraged to take part in hands-on experiments and learning projects, My teaching practices focus on problem-solving and critical thinking skills, Group activities and collaborative learning methods are

regularly used to promote STEM learning, My school has adequate laboratory facilities to support STEM-related activities, Digital tools (such as computers, multimedia, and internet) are available for teaching STEM subjects, The school curriculum supports the integration of STEM education, Have you ever had any STEM training?, and Students in my school show motivation and interest in STEM-related subjects. The majority of the participants showed their disagreement with all the twelve statements mentioned above, strongly disagreeing and disagreeing with the statements, this depicts that the intimacy of STEM Education among the respondents is not up to the mark. However, the same pattern has been seen in terms of existing status of STEM Education in the public sector secondary level schools of Quetta. Furthermore, among all the twelve statements the highest disagreement in terms of intimacy is with the statements that 'Teachers in my school have sufficient understanding of STEM principles.', and 'Have you ever had any STEM training?'. However, the highest disagreement in terms of existing status of STEM has been recorded in the statements that 'My school has adequate laboratory facilities to support STEM-related activities' and 'Digital tools (such as computers, multimedia, and internet) are available for teaching STEM subjects'. This clearly reflects that the adequate laboratory facilities and availability of digital tools are not up to the mark in the public sector secondary level schools of Quetta to support, facilitate, implement, and pursue STEM education among those schools.

Strategies used by the Teachers

Twelve indicators were reflected in the Questionnaire to gauge the strategies used by the teachers for teaching and learning in public sector schools and check that these strategies are in line with the effective implementation of STEM education. The findings shows that the majority of participants always, often, and sometimes utilize these strategies to enhance STEM education in their classrooms, this ultimately shows that their intimacy to STEM Education is not up to the mark. Among the mentioned strategies, the majority used the strategy of identifying similarities and differences. In contrast, the least used strategy was 'Home Work and Practice'.

Previous studies emphasized that STEM education should give importance to applying scientific and mathematical principles to real-world issues and encourage hands-on, inquiry-based, and problem-solving learning in an environment (Kelley et al., 2020). In this study the results revealed that, problem-based learning, inquiry-based instructions, students-led projects, videos and images and setting objectives and providing feedback, are the techniques which are never used by the majority of the teachers in their classrooms, it is also evident from the descriptive statistics as the mean calculated against all these strategies are low as compared to the other strategies. Moreover, these all strategies are crucial for the effective implementation of STEM Education and the development of students' cognitive skills.

Among those never used strategies, problem-based learning and inquiry-based instructions are the foundational element of the SETM Education, these strategies develop critical thinking and problem-solving skills among the students. Whereas, students-led projects, videos and images, and setting objectives and providing feedback

are the strategies which are vital for the concept clarity and also for the enhancement of innovation and creativity trait among students. This reflects that, the intimacy of the STEM Education among the teachers of the public sector schools are not in line with the pace of this technological world, due to the dearth of exercising STEM Education delivery strategies.

However, supporting experimentation and problem-solving in the classroom encouraged students to design solutions to real-world problems, as highlighted by Black et al. (2021). Smart classrooms, which are an upgrade of digital classrooms (Boss & Krauss, 2022), can integrate various advanced technologies (Chiu et al., 2021) and are appropriate for interactive STEM lessons and tasks, for applying enhanced teaching, motivating students, and developing their abilities (Coté, 2024). Engaging students in collaborative, project-based learning experiences fosters a sense of curiosity, problem-solving skills, and a positive disposition towards STEM disciplines (Moore et al., 2020). Active learning is essential for STEM education, which requires students to actively participate in the learning-by-doing process and think critically about what they are doing (Yaki, 2020). The engineering design process used in STEM and the problem-solving steps are similar; therefore, STEM supports and develops problem-solving skills, as also emphasized by Yıldız-Feyzioğlu and Demirci (2021).

6. Conclusion

The study concluded that the intimacy of STEM education among the public sector secondary school teachers is meager, and the existing status of STEM education in the public sector secondary-level schools is also not satisfactory for the implementation of STEM education. Furthermore, the teaching strategies which are being used by the teachers are not in line with the feasible implementation of STEM education. In addition, the teacher training initiatives should be taken by the authorities, and training programmes related to STEM should be incorporated in the teachers' trainings for the development of intimacy and understanding of STEM principles among public sector secondary school teachers. Moreover, for the enhancement of the existing status of STEM education, adequate laboratory facilities and availability of digital tools should be ensured for the successful transition from traditional methods of teaching to the market-advocated approaches. Additionally, the motivation among teachers should be raised by arranging seminars, workshops, and exhibitions related to the STEM Education and also, they are instructed to integrate STEM Education in their teaching and learning strategies.

7. Recommendations

- STEM related training opportunities should be shaped in accordance with the availability of resources.
- There should be competent and well-trained educators to deliver a STEM-integrated curriculum, and the faculty needs to be trained in implementing and disseminating STEM education.

- Continuous professional development programs can be offered through seminars and workshops, and there is a need to provide teachers with ongoing professional development opportunities to improve their STEM instructional abilities and stay informed about best practices. In addition, there is a need for collaboration among STEM teachers to develop and share effective teaching strategies and resources.
- There is a need to use innovative pedagogical approaches and a learning management system to create an interactive learning environment that positively impacts the learning performance of students.
- 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, including teachers' training and infrastructure development. Furthermore, regular monitoring and evaluation are required to explore the effectiveness of STEM education programs to inform policy decisions and drive improvement.

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