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Obstacles Faced by Primary School Teachers in Implementing STEM Education: A Cause for Concern

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ABSTRACT

Societies are empowering individuals with the skills and knowledge needed to thrive in the 21st century and contribute to a more sustainable, equitable, and prosperous future. The need for Science, Technology, Engineering, and Mathematics; STEM education is a multifaceted concept that plays an important role in preparing students in a complex and technology-driven world. Despite numerous benefits, certain obstacles exist that impede its effective implementation and widespread adaptation. The current qualitative research was structured to explore the obstacles faced by teachers in implementing STEM education in Kasur, Punjab-Pakistan. The authors conducted an interview protocol from randomly selected 20 teachers working in public sector schools. The results of the thematic analysis confirm that the struggle to implement STEM education schools' councils' poor involvement, low availability of computers and internet, lack of teachers' training, poor application of innovative teaching methods, deficiency of science teachers, non-availability of STEM curriculum, administration constraints, availability of funds and laboratories were the main hurdles faced by teachers in implementing STEM education. It is recommended based on the findings that the School Education Department; SED hires science teachers, establishes laboratories, conducts teachers' training, and invests a handsome amount to fulfill the deficiency of STEM hurdles, a cause for concern.

Introduction

Science education is essential for fostering a scientifically literate and empowered society capable of addressing challenges effectively. It promotes critical thinking, problem-solving, innovation, and ethical awareness while providing individuals with the knowledge and skills needed to thrive in a rapidly changing world. Science is the understanding of nature and ways of knowing for scientific knowledge. Science is practical, inferential, innovative, hypothetical, and socially and culturally influenced (Lederman et al., 2002). Science is the body of knowledge and continuous, extended, refined, and revision of continuous processes. Science generates an individual thirst for desires (Simmie, 2007). Science education is not exceptional in this century. At the start of 1983 National Council for Educational Excellence (NCEE) estimated that the USA was under threat due to a lack of ability in five fundamental areas: mother tongue math education, social studies, computer science education, and science education (NCEE, 1983). Above mentioned areas were offered for national development at the root level to overcome this deficiency (Zuga, 2004). Science became

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a compulsory subject from the primary and elementary levels and is considered a painstaking subject (Halai, 2008). The government of Pakistan sets objectives, arranges meetings with stakeholders, and constructs a curriculum focusing on students' cognitive, social, and educational abilities to achieve objectives (Government of Pakistan, 2006) which are achieved through implementing national curriculum guidelines with the help of head teachers, teachers and students (Government of Pakistan, 2009). The national curriculum for general science is in sound writing (Government of Pakistan, 2006) and its implementation is a weak feature that significantly affects students' learning (Lee & Chue, 2013) still a debatable part of diverse areas of curriculum studies (Clarke & Hollingsworth, 2002).

Etymologically "S" for the science of STEM focuses on the understanding of the natural world, body of knowledge, and collection of facts that lead to understanding and discovery of new knowledge (Pandarinath & Bensmaia, 2022). It inputs the existing knowledge and makes the students able to question, hypothesize, investigate, and interpret facts applying scientific standards dealing with physics, chemistry, and biology, whereas "T" for Technology (Van Veldhoven & Vanthienen, 2022) refers to the adaptation of natural world focusing humans' wants, necessities and thrust digesting man-made products used in natural material/resources (Lee et al., 2022). It centers on what can/should be the plan, implement, and industrialize universal resources to fulfill individual desires. Besides, the "E" of Engineering (Mitcham, 2022) is based on an understanding of knowledge via logical justification exercising material resources for human benefits (Jevons, 2022). Meanwhile, the "M" of Mathematics is concerned with scientific patterns and strong links that give literal words for technology, science, and engineering (Hikmat, 2022) that are considered interdisciplinary learning (Morrison, 2010) and instigate students' higher-order thinking (Bodde, 2022). The proponents of Science, Technology, Engineering, and Mathematics; STEM laud its potential to engage students towards 21st-century skills (Silander, 2022) sustain the quality of education (Frahm et al., 2022), and strengthen the pipeline of individuals toward STEM careers (Kelley & Knowles, 2016). In society, all sorts of humans are significantly contributing to Science (Beck et al., 2022) Technology (Feerick et al., 2022), Engineering (Alam et al., 2022), and Mathematical (De Ridder, 2022) knowledge and daily life applications. It ignites students' curiosity towards learning (Sun et al., 2022).

STEM education is a less traditional mode of education. It whips learners' eagerness toward better achievements during teaching teaching-learning process (Lu & Kaiser, 2022). Curriculum, textbooks, teaching methodologies, and students' assessments are the key aspects of general science curriculum effectiveness including STEM education (Just & Siller, 2022), work as catalysts and fill the gap in general science curriculum implementation. They have impacts on students' knowledge and have great concerns about Students' Learning Outcomes (SLOs). They develop students' understanding and teaching-learning material on STEM education according to the guidelines provided in the curriculum document (Sadia, 2022). It is arranged in the form of textbooks, teacher guides, teaching strategies, students' assessment procedures, and activities of teaching and learning. Teacher training is arranged to improve teachers' strategies (Malik, 2017).

Scientific innovations are reaching the doorstep of every individual (Horowitz, 2022; Wulan & Astuti, 2022). Students outflow from the traditional education system and apply attained STEM knowledge that promotes students' thinking potential and computationally solves real-life problems in practical life (McKeown et al., 2022; Sluss et al., 2022). Students' overall cognitive and educational development demands respondents' energetic classroom involvement to achieve set targets. Purposeful teaching is reflected in terms of students' better achievements (Thai et al., 2022). Concerns of STEM education able Pakistani learners towards *a*) provision of solid foundations of STEM education to cope with life and 21st-century skills, *b*) the era of the 1960s factually changed with skills that erase manual tasks and increased technical/hands-on skills, *c*) proper training for job acquisition, *d*) gaining of advance STEM education for learners' future success, *e*) collaborate STEM education with another walk of life; industry, institutes, policymakers and parents to inspire future scientists, engineers and statisticians (Awan et al., 2017; Dogar, 2020; Malik, 2016).

STEM education in Pakistani educational institutions is spreading day by day (Hali et al., 2021). Pakistani students consider that Science; an amalgamation of physics, chemistry, biology, Engineering, and Mathematics are conceptual subjects, whereas Technology is an entertaining and heart favorite subject that has a concrete effect on students' long-life learning (Hali et al., 2021). Teachers arrange fewer activities in classrooms to raise students' critical thinking and problem-solving skills to promote STEM education (Hammad, 2020). It is also one of the reasons that teachers apply traditional teaching approaches and beyond to be part of the smooth running of the mainstream education system. Students outflow from the traditional education system and attain STEM knowledge prepare students' thinking potential and computationally solve real-life problems (Ibrahim & Syed, 2022). Resultantly, students' computing engineering physical

science, life science, and mathematical knowledge increased potential (Shaikh et al., 2019) demand school initiative in finding the answer to real-world problems.

Statement of the Problem

Teachers set targets, conduct activities, and apply potential in the classroom to obtain set objectives. When the teacher applies instructional techniques and conducts hands-on activities applying low-cost and no-cost material, it makes students reflect on concrete learning. They are skilled through practice teaching, preparing lesson plans, and presentations, and conducting diverse activities to implement STEM education. The teaching of science at the primary level is still in the trailing phase (Halai, 2008) due to poor implementation of science curricula (Nawaz, 2020) and traditional teaching methods (Hassan & Akbar, 2020). Resultantly, annual PEC results showed poor achievement scores; 45% in a science subject (Mahmood, 2013) and still declining due to stakeholders' slackness. The applications of traditional teaching to contemporary approaches in preparing students for success are the aim of states. STEM is a discipline that faces several obstacles depending on context and region. It needs to be explored to prioritize STEM education. In this regard, the researchers' teaching and managerial experience inspired them to explore the current teachers' involvement in fulfilling present-day students' STEM needs. Current research is an effort to explore current obstacles faced by the teachers in the implementation of STEM education practices in District Kasur. By addressing these challenges, policymakers, educators and community leaders can cultivate a more diverse, equitable, and innovative STEM workforce capable of tackling the complex challenges of the future.

Research Design and Methodology

To get in-depth insight from the participants about the implementation of STEM education, the authors adopted a qualitative research design. This design has a unique importance in gaining an understanding of participants and fostering respondents' participation in diverse subjects. The authors delve deeply into a complex phenomenon (STEM education) exploring, perceptions, and detailed experiences having intricate social phenomena enriching enriches understanding in-depth understanding is valuable for gaining insights into complex educational constructs.

Population and Sample of the Research

The current research was conducted in District Kasur, Punjab which has a 60.77% literacy rate of males and 53.45% of females. Administratively, District Kasur is divided into Tehsil Pattoki, Chunian, Kot Radha Kishan, and Kasur with 57% enrolled children 3-5 years of age and 85% children of 6-16 years of age in public and private sector educational institutions with 50,50 percentage (https://aserpakistan.org/document/aser/2012/drc/punjab/Kasur.pdf). The present research was conducted only in public sector primary schools of Tehsil and District Kasur, where the Government of Punjab has recently initiated the idea of STEM education including 43 District of Punjab (https://punjab.gov.pk/districts). Currently, 1,982 primary school teachers in 541 male schools are disseminating science and arts knowledge among primary school students (https://schoolportal.punjab.gov.pk/sed_census/new_emis_details.aspx?distId=351--Kasur).

The authors selected twenty primary school teachers to conduct an interview protocol on STEM teaching. The authors selected those teachers having science experiences and were selected as Elementary School Educators; ESE based on science background and was recruited as ESE (Science+Math). During piloting, the researcher came to know the shortage of science teaching staff and infrastructure. In this regard, the authors conveniently selected 20 teachers to interview STEM implementations. The aspects of ethical considerations were kept in focus. The heads of the institutions and teachers were assured that the collected data would be used for research purposes only. The authors ensured the fortification/authorization of ethical considerations; informed consent, anonymity, confidentiality, the potential of harm, and no physical and psychological loss in case of respondents' volunteer participation.

Instrumentation

In qualitative research, to collect data from the participants, interviews play an important role in obtaining participants' in-depth understanding of observable phenomena. Likewise, the authors constructed an interview protocol having 10 questions about the implementation of STEM education. After a review of the literature, meeting with the experts, and observational studies, the authors found that different problems are being faced by the teachers working in public sector primary schools. In this context, the construction of the interview protocol assists the researchers in exploring in-depth problems faced by the teachers. The initial items of the questions consisted of 10 open-ended statements. These were validated by the experts in curriculum, pedagogy, and English language, who made slight changes in items.

Data Collection Procedure

The researchers initiated the process by contacting experts via telephone to arrange appointments for visits. Subsequently, they individually visited each participant at the agreed-upon date and time, outlining the

study's purpose and seeking their consent for collaboration. The authors ask open-ended questions to encourage detailed responses and allow participants to express their thoughts freely. The authors actively listen to the participant, ask clarifying questions, and probe for deeper insights when necessary. Authors use active listening techniques to ensure accurate understanding. Begin by establishing rapport with the participant and creating a comfortable environment. The authors ensured the aspect of ethical considerations during the interview protocol including confidentiality, anonymity, and respect for participants' rights. Protect sensitive information and obtain ethical approval if required by your institution or organization.

Data Analysis and Interpretation

This part of the article consisted of data analysis and interpretation. After conducting the interview protocol, the researchers made a thematic analysis. The codes were sorted out and against each code, the authors interpreted the themes in descriptive forms, given below:

Interview Question 1: Although School Education Department; SED is struggling to implement STEM education. Without hurdles, this will be faced to put into practice

Sixteen out of twenty teachers assured that SED needs to increase the amount in primary schools as per students' enrollment will be the major hurdle. Moreover, the establishment of laboratories in primary schools, recruitment of science teachers, and availability of computer labs and internet facilities will be obstacles for the officials. Four out of twenty participants confirmed that heads of institutions and science teachers must be provided training to implement the idea of STEM education. They have just conducted competitions entire province of Punjab in which teachers were instructed to make a video of students' STEM activities. Based on activities, the government of the Punjab has nothing provided to the teachers to purchase, manage, and direct the students. The entire credit for the preparation of the STEM competition goes to the heads of the institutions. Nothing was provided to the teachers for STEM preparation. Students and teachers invested their pocket money and tried their best to participate in competitions.

Interview Question 2: The government of the Punjab is showing serious concern about the smooth running of School Councils. What sort of hurdles are there regarding school councils' involvement in implementing STEM education?

Twenty out of twenty participants assured that although schools' councils are working in public and private sector educational institutions role in enhancing STEM education is passive. There are other responsibilities of school councils like students' enrollment, admission campaigns, maintenance of schools' infrastructure, students' welfare, private teachers hiring, availability of teaching material, and less focus on STEM education. Teachers ask heads of the institutions to share and discuss the current initiatives and make the best options to implement them. Certain hurdles among, teachers, head teachers, and the schools' council members are

Interview Question 3: For the implementation of STEM education, the importance of computers and the internet is very important. Share your feelings accordingly

Twenty out of twenty participants stated that in entire public sector schools of Punjab, there is hardly any facility for computers and the internet is available. The teachers are unable to cope with techniques, and innovations and cannot update their knowledge. However, there is a tablet available in schools, where the school's tab is free and interconnects are also connected; can use it for educational purposes. Mostly, it is busy with data updating, data entering, data correcting, and forwarding official documents to the officials for record purposes.

Interview Question 4: Teachers' training is an important part of implementing STEM education. What are the problems of teachers' training in the SED?

Twenty out of twenty participants confirmed that in the last six years, SED has hardly conducted training due to political instability in the state. New recruitment has been pending since last year and teachers are overburdened. There is also a lack of science teachers. In many of the schools, single-paying services among students. Due to a lack of teachers' training, the performance of teachers is poor and needs to be uplifted. They further stated that lack of training has far-reaching consequences on students' performance in STEM teaching and quality of education. Providing teachers training is not the priority of SED due to plenty of problems.

Interview Question 5: The application of innovative teaching methods is important for the teaching of STEM-teaching. Do you lack in the use of teaching approaches?

Sixteen out of twenty participants in SED the teachers are still applying traditional teaching methods in public sector schools. It is one of the hurdles the teachers have been facing for years. Resultantly, they are hardly able to engage, participate, and develop STEM skills. Four out of twenty participants reported that while acquiring a professional degree, we were being taught teachers-centered, still using during teaching STEM teaching that is not up to the mark. The schools are less focused on hands-on and peer share and

activities.

Interview Question 6: there is a severe deficiency of science teachers in public sector schools. How do you overcome the deficiency to cope with students' STEM needs?

Fifteen out of twenty participants stated that teachers' deficiency is a major obstacle in public sector schools. Heads of the institutions combine the class and just a single teacher manages the students with passion and enthusiasm. There are overcrowded classes that make it hectic for the teachers. Five out of twenty teachers confirmed that heads of the school have hired teachers from *Non-Salary Budget* and *Ferog-i-Taleem* funds to fulfill teachers' deficiencies.

Interview Question 7: there is a non-availability of the curriculum in the school education department. How do you obtain guidelines to implement STEM education?

Twenty out of twenty participants confirmed that public sector institutions lack in the curriculum. The curriculum is the backbone of any education system that assists teachers in organizing, presenting, structuring, and delivering the lecture effectively. They stated that we follow the directions given by the SED and high-ups. We are bound to follow the directions imposed by the officials. The lack of a curriculum is also a big obstacle for teachers to follow the guidelines. Most of the time, we have to take ideas, prepare STEM lessons, use teaching methods, after leaving schools, search libraries, and use social media.

Interview Question 8: what sort of administration constraints you are facing in implementing STEM education among students

Twenty out of twenty respondents expressed that for many years we have been facing obstacles in implementing STEM education. Higher authorities assign tasks exams duty, dengue activities, polio duty, paper marking, clerical tasks, recruitment duty, plantation, conducting meetings, census duty, private school students' enrollment; and overcrowded classrooms are the hurdles faced since decades. Administrative authorities assign tasks to the heads that are further assigned to the teachers. When the teachers take a stand against the extra/irrelevant duties the department comes into action and imposes penalties for misconduct and inefficiencies.

Interview Question 9: do you feel that the less availability of funds is an important hurdle in implementing STEM education

Twenty out of twenty teachers assured that public sector schools are not provided sufficient funds in account of STEM education. Lack of funds hinders the efforts of teachers to provide high-quality STEM education. Due to a lack of funds, the teachers are deficient in conducting activities and purchasing STEM-related material. Moreover, due to a lack of funds, teachers have limited access to resources, outdated infrastructure, and limited technological gadgets which are obstacles to implementing STEM needs. When there is less availability of funds, they are hardly able to purchase instructional material. By addressing funds obstacles in STEM implementation, students will be empowered with skills, the latest knowledge, and 21st-century skills and will contribute to a more innovative and prosperous state

Interview Question 10: to implement STEM education, the availability of laboratories plays a worthwhile role. How do you overcome this deficiency?

Twenty out of twenty teachers are convinced that the idea of STEM education in SED is new, so the establishment of laboratories in primary schools is new. It will be structured with time. It is one of the problematic aspects of not having a laboratory in schools; we are unable to experiment and conduct hands-on activities. They further reported that students lack practical understanding, scientific literacy, and real-world applications. The participants further stated that due to the non-availability of laboratories, are hardly able to prepare students for future success, lack in fostering innovation and creativity, and are weak in skill individuals to tackle future and global challenges. Lack of laboratory is one of the major obstacles in conducting experiments, providing hands-on learning, and reducing STEM skills. Without access to laboratory facilities, students lack practical, observation, and inquiring questions to understand STEM concepts.

Discussion

Teachers, students, classrooms, and the education system affect on intended, implemented attained curriculum. States are focusing on the entire development of their students in STEM education. The results of the current research revealed that teachers are facing a diversity of obstacles in implementing STEM education which aligns with the findings of the research conducted by Aslam et al. (2023) which confirms that tension existed between teaching beliefs and acquiring goals in STEM teaching. Teachers' content knowledge, pedagogical potential, and professionalism are important indicators in implementing STEM teaching. Teachers' lack of pedagogical skills also poorly disseminates STEM knowledge among students (Hill et al., 2005) which supports the results of the current research. Likewise, teachers' acquisition of more pedagogical knowledge, has a long-lasting effect on students' STEM understanding (Goldhaber & Brewer,

1998; Monk, 1994). In this regard, there is a need to revise science standards and other STEM subjects (Deines, 2011; Hibpshman, 2007). The findings of the current research established that teachers' training was a big hurdle in implementing STEM education congruent with the findings of other studies (Sawchuk, 2011), emphasis on improving teachers' training for science teachers (Hibpsman, 2007). The findings of the current research also aligned that lack of funds utilization (Herrick, 2011; Mervis, 2011) and traditional teaching methods were the obstacles to implementing STEM education (Nwanekezi &Nzokurum, 2010) that failed to enhance students' curiosity and self-guided inquiries. Moreover, According to Krueger and Whitmore (2001), the classroom is the primary space where students spend the majority of their time. It was found that decreasing class size can lead to increased academic achievement, particularly for students from low-income backgrounds. Thus, it is crucial to create a conducive learning environment within the laboratory. Schools are facing problems with the necessary infrastructure, equipment, and instructional media for effective STEM education. The government and school authorities ensure the employment of a sufficient number of STEM educators to facilitate teaching-learning. Where teaching materials are inadequate, teachers develop the skill of improvisation (Ejiwale, 2012; Nwanekezi & Nzokurum 2010).

Conclusion

Teachers invest their cognitive and social potentials to impart instructions among students to promote education / STEM education which plays a significant role in developing students' concerns towards education. Teachers focus on students' learning outcomes; and SLOs and deeply develop students' understanding of STEM education. It is concluded that primary schools of District Kasur are facing plenty of obstacles in implementing STEM education. The poor concern of schools' councils is alarming, whereas, the availability of computers and internet facilities with technological gadgets are obstacles for the teachers. Due to the non-availability of laboratories, poor availability of STEM curriculum, administration non-directional concerns, shortage of science teachers, and lack of teachers' training are the major obstacles. By overcoming the obstacle of siloed STEM education and fostering interdisciplinary approaches, teachers can better prepare students to tackle complex, real-world challenges and succeed in STEM-related fields. By addressing these challenges, stakeholders can cultivate a more diverse, equitable, and innovative STEM workforce capable of tackling the complex challenges.

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