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Challenges in Implementing STEM Education: Insights from Novice STEM Teachers in Developing Countries

Sarfraz Aslam ^{1,2,*} , Abdulelah A. Alghamdi ³ , Nisar Abid ⁴  and Tribhuwan Kumar ⁵¹ Faculty of Education and Humanities, UNITAR International University, Petaling Jaya 47301, Malaysia² International Council of Associations for Science Education (ICASE), T12 Cork, Ireland³ Faculty of Education, Umm Al-Qura University, Makkah 24382, Saudi Arabia; aaghamdi@uqu.edu.sa⁴ School of Social Sciences and Humanities, University of Management & Technology Lahore, Lahore 54770, Pakistan; nisar_abid_88@hotmail.com⁵ College of Science and Humanities at Sulail, Prince Sattam Bin Abdulaziz University, Al Kharj 16273, Saudi Arabia; t.kumar@psau.edu.sa

* Correspondence: sarfrazmian@nenu.edu.cn

Abstract: Economic growth has been attributed to STEM education in many countries. It is widely recognized as crucial to improve science, technology, engineering, and mathematics (STEM) education, especially for traditionally disadvantaged groups. In this age of the fourth Industrial Revolution, we are going through a rapid change. Several difficulties have been associated with STEM's implementation, particularly troubling developing countries. In this article, we investigated STEM teachers' unique challenges in their classroom experiences and how these factors influence their instructional practices and students' learning outcomes. STEM teachers' teaching reflections at the secondary level were examined in this qualitative study. A purposive sampling method was used to recruit ten novice STEM teachers. The data were analyzed using NVivo11. Despite their disciplinary expertise and the variety of teaching methods they employed, the teachers faced numerous challenges. Teachers faced difficulties managing classrooms, developing curriculums, and recognizing practical constraints in STEM education. Teacher beliefs about effective STEM education, the tension between these beliefs and the teaching goals of the teachers were closely linked to the teachers' beliefs about effective STEM education and the educational system's expectations. For STEM teachers, the mastery of content knowledge is critical. A regular exchange of experience is of significant help to teaching. Teachers' pedagogy and professional development in STEM education are discussed concerning underdeveloped countries' contexts. Researchers and educators in developing countries might not understand STEM education's significance. The reason may also be that STEM education in developing countries faces several challenges.

Keywords: STEM education; sustainable development; secondary school; quality education

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1. Introduction

The United Nations adopted sustainable development as a blueprint for peaceful, prosperous communities and planets in 2015. All developed and developing countries must collaborate in a global partnership to achieve the 17 Sustainable Development Goals (SDGs). In addition to addressing poverty and other adversities, they recognize that improving health and education, reducing inequality, and spurring economic growth are all necessary to end poverty and other deprivations [1]. Achieving SDGs requires effective education [2]. Educational institutions' role in society is fundamental, given that they often educate the next generation of employers and leaders [3], education Policy (2017) Pakistan, which for the first time emphasizes education for sustainable development's (ESD) role in achieving the SDGs, recognizes both SD and ESD's importance in achieving the SDGs [4]. Even though the National Education Policy contains 19 educational goals related to ESD [5], the situation of ESD and its role in achieving SD has been explored in a few studies in recent years [6].

STEM is an approach to learning and development that integrates science, technology, engineering, and mathematics [7]. STEM education is centered on recognizing that interdisciplinary education should occur permanently in all contexts and with a deep understanding of reality (life-long, life-wide, life-deep) [8]. STEM education involves multidimensional knowledge of hands-on practice. It is a pedagogy and a philosophy to embed the new generation with the 4Cs framework, i.e., communication, collaboration, creativity, and critical thinking [9]. The quality of instruction in the STEM classroom is optimized with a firm basis from the experiences of students tested in dynamic learning environments equipped with laboratory, fieldwork, and online experiences [10,11]. STEM classrooms connect the students to real-world challenges that blend dynamic digital content into get-in-there and hands-on activities, which helps to accelerate student applications [9].

STEM education stays in high demand across most countries because, along with the influence of science on daily life, it provides the opportunity for scientific knowledge and collaboration of scientists, engineers, and technicians in the economy of an ever-growing, globalized world [12]. Many countries consider STEM education essential to economic growth. The subject has attracted the attention of a wide range of educational institutions. In developing countries in Asia, it has triggered several problems due to the lack of actual implementation [13,14].

A STEM professional development program is necessary to help teachers understand the nature of integration and make explicit connections between science, technology, engineering, and mathematics [15]. In recent years, there has been a global STEM education movement; the STEM curriculum has evolved over the last 25 years from a convenient clustering of four competing disciplines to a more coherent skills base and capability set essential for the 21st-century economy. Academic institutions worldwide are embracing STEM education and related curricula, with government sponsorship in many cases.

AS Ferrari [16] explored that in 2001, the US National Science Foundation coined the term STEM. Concerns that students were not prepared adequately for high-tech jobs in the twenty-first century sparked the STEM movement. The results of international studies like Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) reaffirmed concerns about students' scientific competency and skills and prompted international comparisons. Global awareness has made STEM education more critical than ever [17]. The words "STEM," "STEM education," or "STEM education research" were used to identify more than 4,540,000,000 (0.55 s) products on Google. It demonstrates the rapid advancement of STEM education as well as the extensive research that has been conducted on it [13,18].

Aslam et al. [13] explored that Pakistan is now facing a new era of educational reforms, and the world is rapidly changing to learning in the twenty-first century, and adaptation and development of the quality of education are needed. Schools must implement innovative education holistically, combining learning progress with prior knowledge. Pakistan's K-12 and tertiary education systems are not sufficiently aware of STEM, even though it is an essential component of 21st-century education. In recent years, STEM education has been the subject of several initiatives across Pakistan.

STEM education in Pakistan has an abysmal record because the country ranks amongst the lowest in the world regarding STEM literacy. This is a massive problem because STEM education is essential for a country's economic development and competitiveness [19]. Currently, no STEM-based teaching techniques are being followed in classrooms in Pakistan. A significant factor that has contributed to the decline in the quality of science education in Pakistan and the adoption of global trends is the lack of trained faculty. Studies have clearly shown that teacher training is insufficient to accelerate STEM education. Access to labs and qualified faculty during primary and secondary education could be a breeding ground for future STEM students [20].

STEM education has been understood as an interdisciplinary approach that aims to connect independent disciplines to help students solve authentic problems [14]. In order to prepare students for careers in STEM fields, improving academic skills in STEM disciplines

has become an international priority [21]. To prepare future STEM-literate citizens, teachers are key, and their preparation for STEM teaching is essential [22].

1.1. Difficulties and Challenges

Different stakeholders interpret STEM education differently, making it difficult to regulate, especially when developing worthwhile STEM pedagogies [23]. It is difficult to conceptualize STEM pedagogy when one crosses from one STEM disciplinary knowledge domain to another due to an epistemic obstacle [23]. An epistemic obstacle in learning results from a student's limited understanding of a concept that creates a barrier to the learning process; students may experience difficulties when applying their previously acquired knowledge if faced with a different concept [23]. A STEM education student is often required to transition between scientific, mathematical, and technological learning areas while engaging in modeling processes, which creates a synergistic relationship between the disciplines. These processes are often interdependent as a result [24]. The concept of boundary crossing between different knowledge domains is crucial for addressing the complexity of integrated STEM pedagogy. Pedagogical content knowledge gaps in the disciplines need to be bridged by mediating objects. The presence of a boundary, which contains common concerns on both sides, should be viewed as an opportunity for learning instead of an obstacle [23].

STEM integration is not a one-size-fits-all solution (Figure 1) [25].

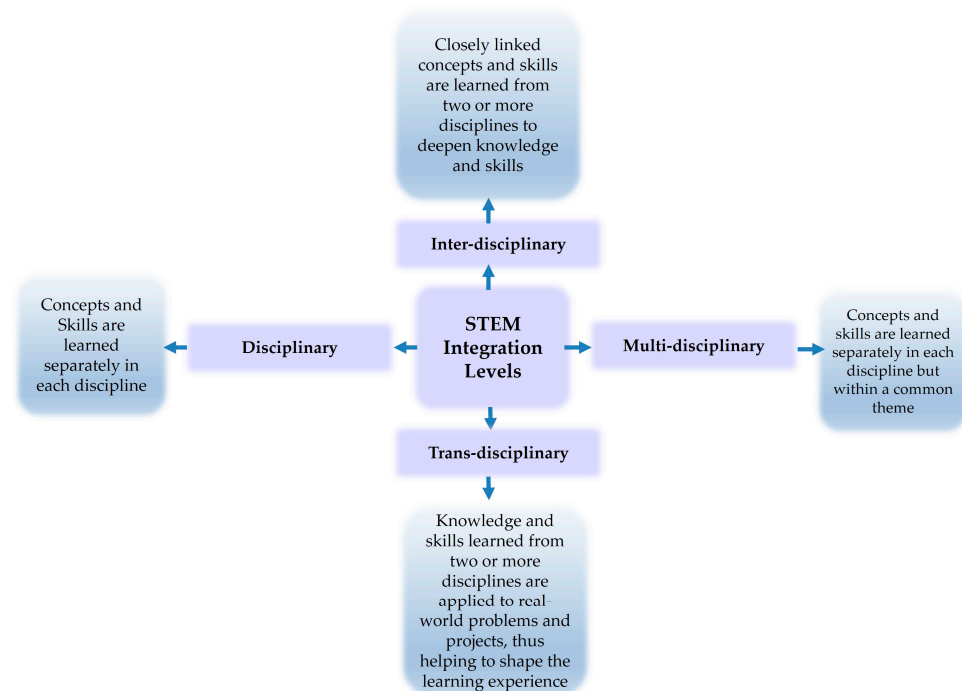


Figure 1. Incorporating STEM in different levels of a continuum of integration.

In STEM classrooms, the segmented content area needs to be included, emphasizing technology to connect the subject matter related to teaching to the outside world [26]. Critical thinking applies to STEM learning and is the basis of STEM curricula. It allows assessing students' abilities to apply their knowledge to problem-solving [27]. Since STEM education is an emerging approach, most educators, especially novice teachers, may grasp the concepts differently [28].

The level of teacher competence (pedagogical content knowledge, self-efficacy, and teaching enthusiasm) is positively related to student interest and self-efficacy. The three dimensions of teaching quality (cognitive activation, supportive climate, and classroom management) all refer to the interactions between the teacher and students in the classroom [29].

Few teachers follow discipline integration teaching guidelines or methods, and few teach STEM interdisciplinary integration. The relationship between science, mathematics, and engineering is well known to teachers, but it is not easy to integrate technology into the curriculum. According to some teachers, the problem is the focus on curriculum integration.

In addition to teachers who believe that Math is just a tool for solving disciplinary problems, some teachers believe that STEM is best used in a real-world setting. STEM teachers also face a variety of uncertainties when practicing interdisciplinary integration. Without a comprehensive understanding of multidisciplinary integration, many STEM teachers do not know how interdisciplinary teaching can benefit their students [30].

Although there has been growing research on how STEM disciplines are integrated, there are still many challenges to overcome in practice [31]. STEM teachers' ability to integrate subjects largely depends on personality, discipline, understanding of the school environment, teaching methods, etc. Teachers need support to integrate STEM subjects into national curriculums, educational trends, and school environments. There is also a need for close cooperation between administrators and teachers [32]. Several teachers report a lack of the resources necessary to implement inquiry-based learning effectively [33]. STEM programs can be successfully implemented if these challenges are understood. School administrators and teacher educators should also determine what supports teachers feel would enhance their preparation for STEM careers and degrees [34].

STEM education emphasizes integrating knowledge and solving real problems; therefore, curriculum design and teacher requirements are higher. Several studies have shown that a teacher's knowledge content is crucial for teaching, but only knowledge content cannot support teaching [35]. Teachers must still teach to understand teaching theory, learning theory, curriculum theory, and knowledge [36]. It is the same with the teaching of STEM subjects as well.

The reflective journal (RJ) is an effective assessment tool from the perspective of educators [37]. Reflective writing is valuable in medicine, social sciences, and clinical and professional institutions [38–40]. So, we used novice STEM teacher reflection journals for our research. Only a few studies emphasize the importance of fostering STEM education among stakeholders, namely top management, faculty, and students. Previous studies have limited contributions to a better understanding of STEM education in Pakistan. However, no studies have been conducted in Pakistan about STEM teachers' in-class teaching practice and reflection.

1.2. Theoretical Underpinnings

All levels (national, regional, and local) must participate in the achievement of the 17 SDGs [41]. Achieving the 17 SDGs requires ESD [3]. UNESCO's ESD framework beyond 2019; "focuses on strengthening ESD's contribution to the achievement of all 17 SDGs, focusing on policies, learning environments, teachers and educators, youth as well as communities" [42]. In addition to the ESD Agenda's goal of providing quality education for all, SDG 4 outlines the need for education that contributes to the whole line of SDGs and prepares students to transform the world [43]. ESD is a concept that promotes and galvanizes sustainability within the minds, hearts, and actions of the next generation [44].

Knowledge, beliefs, emotions, and motivation all shape teachers' decisions [45]. In recent years, there has been much productive discussion on this subject [13,18,21,23,28,30,46]. However, fewer studies have been found in Pakistan. Although STEM is an essential feature of 21st-century education and learning, there is a lack of awareness about it in Pakistan, especially at the K-12 and tertiary levels [13].

The problem of practice in this proposed research study is about STEM teachers (adults) who teach K12 classes). One theory that aligns with this research is Andragogy. Malcolm Shepherd Knowles is credited with developing Andragogy; Knowles [47] defined Andragogy as "art and science, which helps adults in their learning." Andragogy is the art of adult learning in which trainers and educators play an active role [48]. Andragogy has become a well-known term of learning associated with a particular approach to the

education of adults [49]. A set of six core adult learning principles (Figure 2) and the five tenets of andragogy alignment of theory (Figure 3) that apply to all adult learning situations was presented by [47].

Six core adult learning principles	
	Adults have to recognize the necessity of learning something before undertaking to determine it
	Adults should be aware of their own responsibility. They are autonomous, self-directed, and responsible for their own decisions.
	Learning is enhanced by the quality and quantity of adult experience; adults enter the educational process with a different set of experiences than youths.
	In real-life situations, adults can apply and cope much more effectively than children.
	Learning is a life-centered (task-centered, problem-centered) activity for adults
	Aside from some external motivators (such as jobs, salaries, promotions), internal pressures are the most powerful motivators for adults

Figure 2. Six core adult learning principles [50].

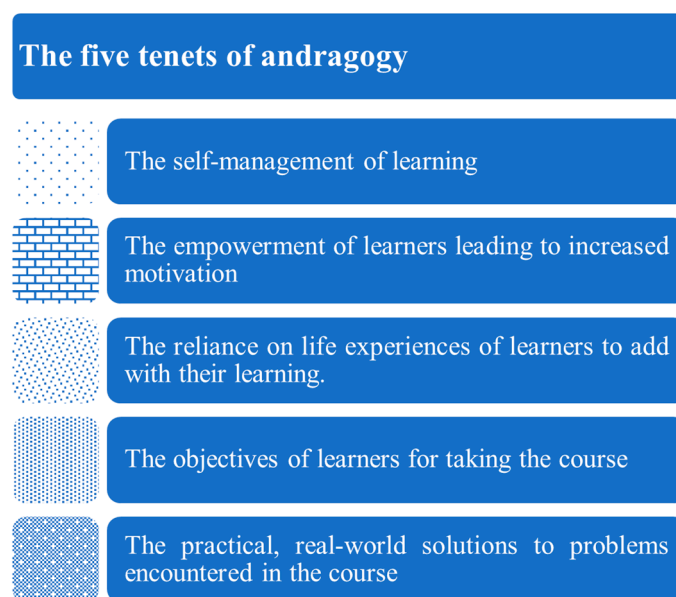


Figure 3. The five tenets of andragogy Alignment of Theory [51].

As STEM Education becomes a key focus for curriculum change and STEM Education takes various forms in different countries, it has become an increasingly important policy imperative globally. The need to consider STEM competencies that will prepare students for productive futures is a key concern for STEM in schools, given the prospect of a vastly changing world of work for current students. The advocacy of interdisciplinary teaching and learning is increasingly aligned with STEM [52].

According to [53], STEM is not just a concept of course content but a process of grooming future scientists, mathematicians, engineers, artists, and technological entrepreneurs. The aim is to prepare youth to think deeply, logically, and critically to become innovators, educators, researchers, and leaders who can solve the most pressing global challenges of the

21st century. While students are well-motivated to learn through a child-centered, problem-based STEM approach, the schooling context has measurable deterrents linked directly to an assessment-driven system [54]. STEM education is the demand of the 21st century because of the influence of science on daily life. Scientific knowledge also plays a vital role in the national and international competition of scientists, engineers, and technicians in the economy of an ever-growing, globalized world [12].

This research study could help inform policymakers and teacher educators and help to improve the quality of the science teaching-learning process of Pakistan through STEM education by focusing not only on pedagogical skills but also the content knowledge required for teaching. The study's conclusions could provide novel, practical, and strategic suggestions to improve the quality of STEM teaching in Pakistani classrooms through innovative and creative teacher training. With the continuous improvement of society's demand for talent, STEM education to cultivate innovative composite skills is being popularized worldwide. Teachers play a key role in ensuring the effectiveness of STEM education. This study aimed to develop our understanding of the STEM teachers' teaching experience in class, problems that may arise in the process of STEM curriculum, and the strategies and suggestions to resolve these problems.

A primary objective of this study was to explore Pakistani novice STEM teachers' challenges to their STEM instructional practices in the classroom. Specifically, two research questions were addressed in the study.

1. What are STEM teachers' unique challenges in their classroom experiences?
2. How do these factors influence their instructional practices and students' learning outcomes?

2. Materials and Methods

An exploratory research design was used for this study. Specifically, this study investigated novice STEM 'teachers' challenges in implementing STEM instruction in the classroom in Pakistan. STEM teachers tend to be those teachers who have specialized in a particular academic field ranging from mathematics, science-related subjects, or even computer science. Several have taught STEM lessons as extracurricular activities, run competitions, or tutored students in STEM-related events. The teachers did not participate in some STEM education programs designed to prepare and train teachers on implementing STEM education. The study used content analysis to analyze the teaching reflection logs of novice STEM teachers and summarize STEM teaching in-class experience. The RJ is an effective assessment tool from the perspective of educators [37]. Reflective writing is valuable in medicine, social sciences, and clinical and professional institutions [38–40].

2.1. Participant and Procedure

Ten novice STEM teachers were recruited for the current study, where females constituted 60% ($n = 6$) of the sample, and males comprised 40% of the total ($n = 4$). A purposive sampling technique was employed, and the sample was selected based on 'Patton's (1990)—sampling principle criterion' [55]. Identifying and selecting information-rich cases for effective use of limited resources is a way to identify and select cases for meaningful sampling (Patton, 2002) [56]. This technique involves selecting individuals or groups with specialized knowledge and experience concerning a phenomenon of interest (Cresswell & Plano Clark, 2011) [57]. Bernard [58] and Spradley [59] emphasize availability and willingness to participate and the ability to communicate experiences and opinions articulately, expressively, and reflectively. An invitation was sent to thirty novice STEM teachers; however, only ten teachers (Table 1) agreed to participate. All teachers signed informed consent to collect the data. These teachers, including science, mathematics, technology, and English, represented different academic backgrounds. Their names were kept anonymous and given pseudonyms, from T1 to T10. Two Model Public Secondary schools (one boys', one girls') from District Okara, Punjab, Pakistan, were selected. In order to provide students with a conducive learning environment, the model schools project would improve the school facilities and infrastructure; a total of 10 schools would be built in each of Punjab's 36 dis-

tricts as part of the plan. There was repeated discussion about the benefit of establishing 10 model schools in each district for students, parents, and teachers [60]. The selected teachers taught ten classes as their regular teaching practice. Each class had an average of 45 students. The STEM courses taught at the secondary level are based on textbooks developed by the Punjab Textbook Board, Lahore.

Table 1. A table outlining the demographics of participants.

Code Name	Gender	Teaching Experience (Years)	Subject Teaching
T1	Female	3	Biology
T2	Female	4	General Science
T3	Male	4	Math
T4	Male	2	Computer Science
T5	Male	3	Chemistry
T6	Female	3	Physics
T7	Male	4	Math
T8	Female	5	Computer Science
T9	Female	4	Physics
T10	Female	3	Biology

2.2. Demographics of Participants

A total of 10 Novice STEM teachers from two model public secondary schools were selected.

2.3. Data Collection and Analysis

The teachers' reflections were open-ended; no outline was provided to them by the researchers. They follow a specific pattern in their school diaries. This study collected 60 teaching reflection texts totaling 18,000 words. NVIVO 11 software was used for qualitative analysis. It ensured that no teacher identification was included in the logs; however, we used pseudonyms for data verification and analyses for each log. The crux of the analysis is coding, sorting out, and categorizing many original data. It includes open, axial, and selective coding [61]. An appropriate sample of respondents was purposefully selected to ensure the reliability of the qualitative data. The interpretation stage is a necessary part of all qualitative research. Each log part was coded and classified by two research team members. Following this, they collectively analyzed the concept underlying the study. Using investigator triangulation, we ensured that qualitative data collection was authentic. Throughout each process, visible validation and reliability of the research were enhanced, as well as ample support for respondents' views on STEM.

2.4. Coding of Data

Open coding: Established many free nodes. The package includes Pre-coding the text first, clarifying words, sentences, and paragraphs, and finding problems and suggestions related to the topic. Pre-coding formed more than 300 free nodes; after formally coding these nodes, 135 of them were repeatedly compared.

Axial coding: By the established freedom, the nodes are classified, and the relationship between the topics of each node is identified. There were 105 free nodes in this study, forming five points: teaching management, classroom teaching, group work, and teachers on STEM recognition and evaluation.

Among them, there is classroom discipline in teaching management. Students' attention, enthusiasm and participation, affirmation, criticism, etc. All kinds of unexpected situations, communication between teachers and teaching assistants and other teachers, etc. In terms of classroom teaching, there is controlling classroom time and content safety, assigning tasks and homework, preparing before class, doing experiments, etc. In terms of group cooperation, there is a clear division of labor so that each member can contribute Strength "and" the phenomenon of fighting, contradiction, and fighting in the group, etc. Problem: Teachers' understanding of STEM includes, content, link do not have a deep

understanding of the various parts of the textbook. The problems include evaluating wrong answers and establishing reward and punishment mechanisms earlier.

Selective coding: Continued to check query and compare original data, sort out the relationship between existing nodes, and find possible logical clues, initial framing of questions, and suggestions.

3. Results

Teachers' Classroom Experiences

Teaching management: The most mentioned aspect of teaching management by teachers is controlling classroom discipline, followed by mobilizing students' attention, enthusiasm, and sense of participation. The four most important aspects are listed in Figure 4.

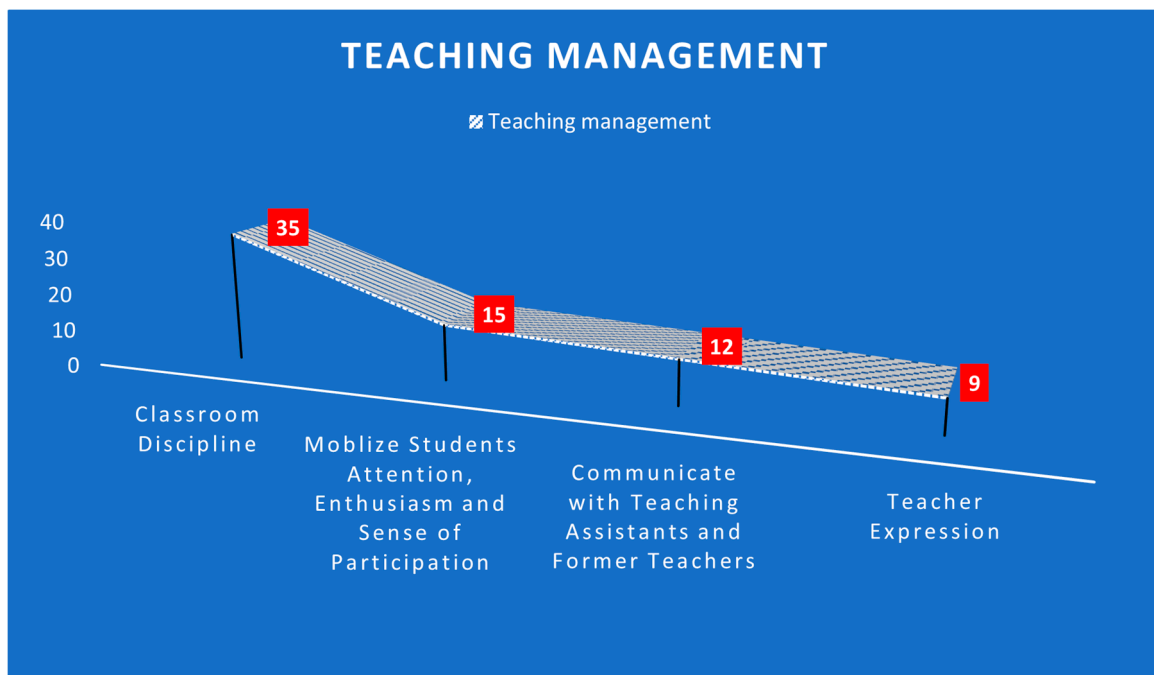


Figure 4. Teaching management-related codes extracted from reflective journals with frequency.

Management of classroom discipline: In teaching reflection, discipline is one of the most challenging aspects. Are novice STEM teachers unable to manage discipline effectively?

Our class does not have effective classroom control, even though the teacher tries to design more exciting lessons. If you do not have effective classroom control, it will not work. (T3)

Discipline is difficult when the teacher is away from the classroom. It is a challenge to keep the students quiet. (T6)

As a teacher, it is not easy to control the order of the class during an experiment and keep the class on track while taking the test. (T1)

When teachers conduct experiments, discipline is tough to control. Sometimes, teachers demonstrate experiments with disorganized discipline; students have sustained injuries due to mishandling of laboratory equipment. In addition to the noise, the limited equipment in each group also caused a scramble. Teachers also have a difficult time controlling discipline because of the classroom layout. Students who watch the demonstration may leave their seats because they cannot see, and jostling may result in chaos.

Moreover, some teachers said they had no idea how to guide naughty students. The teachers suggest many strategies for disciplining students, including highlighting their names, assigning each student something to do, preparing the materials needed for class

before class (study plan, folder, etc.), communicating with individual students during distribution, and engaging students and classes through interaction and games.

Mobilize students' attention, enthusiasm, and participation: Teachers reflect students' involvement and attention in class with remarks such as "I cannot listen to others carefully," "Speak up," etc. Moreover, the teacher provides strategies to increase the students' attention, enthusiasm, and sense of participation. For example:

Some group members do not participate in the group, but more guidance, communication, and taking care of each child would be beneficial. (T2)

Incentives can be used for children with robust, rebellious personalities. For instance, praise his creativity and ask him to show his work. (T3)

Drawing pictures and sharing their most creative work through group discussion is a great way to unleash student creativity. (T6)

According to the four teachers, students who dislike speaking should be encouraged to speak. You cannot just focus on the positive kids and ask them questions. Also, please pay more attention to the children who dislike speaking up and mobilize their enthusiasm.

In class today, a student did not like to speak. After class, we discussed it with her, and she did not respond. With the right encouragement, she became active and raised her hand to speak; motivation is critical. (T2)

Making students think and answer more can motivate them. It is necessary for children who do not raise their hands often or lack a sense of presence to talk to them alone. In addition, it is essential to select simple questions for them to answer; this will increase his confidence and participation. (T4)

Three teachers mentioned increasing inner interaction, giving students more answers, and encouraging students to think. The competition mechanism of the game, a clear division of labor, and the form of video content serve as strategies to attract students to participate in the learning process. Dull content should be improved to attract student interest, develop the game to attract competition, and create videos engaging students. In addition, four teachers mentioned the need for reward and punishment mechanisms and motivating students by praising the group and the individual.

Communicate with teaching assistants and former teachers: Several teachers highlighted the importance of lab assistants and STEM former teachers. Teachers need to communicate and share their experiences, such as:

Other STEM teachers' advice and experience are crucial, and novice organization teaching is enlightening. (T1)

Additionally, some teachers examine the gap between STEM teachers and their counterparts in the original school. It aids in determining how reasonable and feasible it is to arrange the content of classes to meet the needs of students.

Teachers' expression: There is a common belief among teachers that praise improves teaching more than criticism. In particular, encouragement, affirmation, and other methods of persuasion should be used to deal with the naughtier, disobedient subjects in the study of health. Such as:

When I taught, some students lacked discipline and self-management. A student's reasoning ability affects the entire class and other students. So, I picked up the disciplined group and quietly talked to the poor self-management student during the break, praising him first, the smart and positive, then explaining why he did not praise him, finally advising the teacher he could manage himself and wait to see how he would perform. (T6)

At the same time, teachers put forward the following suggestions about classroom expression. Pay attention to the accuracy of professional language, use students' easy-to-understand way of teaching, and use language to organize the natural transition of each link in the classroom. Any hazardous behavior must be rigorously curtailed to ensure safety.

Classroom teaching: In terms of classroom teaching, this research found that most teachers controlled classroom time, followed by experiments. The five important aspects are shown in Figure 5.

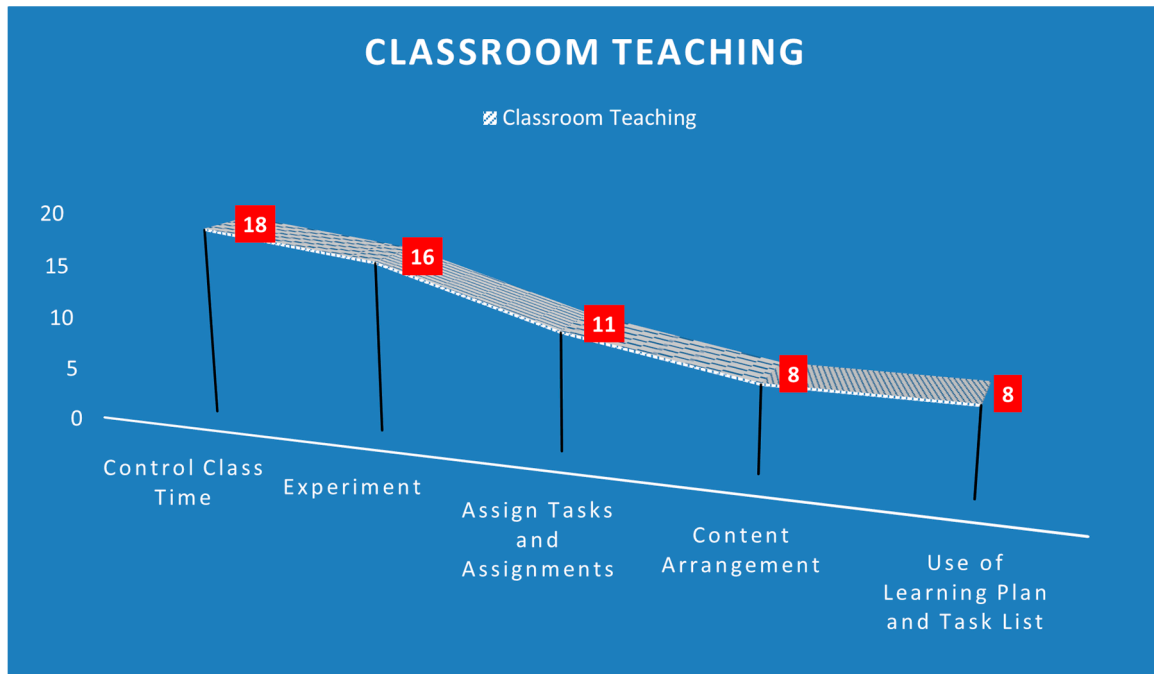


Figure 5. Classroom teaching-related codes extracted from reflective journals with frequency.

Control class time: Regarding controlling classroom time, the teachers focused on the question; I did not have enough time to complete my planned task.

The timing was still a little off. The students didn't design after the final group bird feeder sketch; we can only take it back to design. (T3)

Meanwhile, some teachers pointed out that some tasks are time-consuming and need to be arranged for more time, such as making brand names, drawing, and other activities. Teachers pointed out that too much content leads to insufficient time. For the strategy of controlling class time, the most mentioned is.

When you have a clear idea of the content, you can arrange your class time flexibly. (T2)

The course content should be explicit, according to the other teachers. In conclusion, arrange the course content moderately and prepare sufficient materials for the occasion. It is important to simplify the review and guide for the last lecture, and the course time can be reasonably arranged. (T5)

Teachers also mentioned that students should be reminded to stay in group activities. The rest of the time, focus on the first half of the classroom teaching to explain, avoid No time at last.

The experiment: The major problem is that the experimental material is unsuitable or teachers do not specify using uniform experimental materials. Students bring their inappropriate materials; the experimental materials prepared by the teachers are insufficient. Another significant problem is that it is difficult for students to follow the drawings or experimental record sheets for the flow of experiments—for example, some groups built models without reference to the drawings and randomly selected materials. At the same time, no teachers demonstrate the experiment and appear to leave the seat crowded, scrambling chaotic phenomenon. The teacher suggests emphasizing the division of labor and cooperation with the students and clarifying the group leader. The group leader arranges the roles of the members of the group to ensure that each team member has tasks, such as:

The amount of work must be controlled. Please remember to ask the group leader to come when you take the materials. This will improve the children's ability to cooperate and control the class Sequence. (T4)

Define roles for the children and let them do their work. Many children feel plugged in and actively participate in group discussions. (T7)

A few teachers mentioned that the model should be built strictly with the drawings. The experiment Ended by summarizing the experimental steps.

Assign tasks and assignments: Teachers focused on the problem of assigning tasks to be clear and specific, as in:

All tasks must be clear and understandable. (T6)

The experimental requirements should be precise in advance for the trial production, speak how to use dough (binder), mix material treatment (Need an extra cup and stir bar), and how much water to add, And so on. (T6)

Making tasks specific, both after and in class, lets Children have something to do so they don't talk out of boredom. (T5)

Another teacher offered to bring homework and other things for the next class. Make a to-do list so you do not forget.

Content arrangement: In the reflection, teachers repeatedly reported "unreasonable content arrangement" and so on, such as the lack of contact between various parts of the content and the content arrangement being too much, resulting in the discipline being confused. The strategy given by the teacher is to make the content exciting and engaging People, avoid boredom, and Pay attention to the cohesion between each part of the content; internal appearance arrangement should be understood in the chest.

Use of learning plans and task lists: Some teachers complained that the design of learning plans, task sheets, and other materials was unreasonable. Problems include too much content, lack of time to fill in, and some students not cooperating. Fill in the task sheet. Several teachers suggested that it is necessary to use task lists and case-assisted teaching, such as:

Designing and printing school plans as early as possible in the school year is very important; children have school plans and follow the rhythm better. (T7)

The learning to-do list should be closely linked to the curriculum through. The to-do list assists teaching and makes classroom activities more orderly. (T4)

In addition, some teachers put forward sorting out studios cases and folders before class.

Group cooperation: In terms of group cooperation, the most concentrated problem was Internal group conflict, fighting, fighting, etc., as:

The first half hour of the first session was very disciplined, and the course went well, but the problem was severe in a group discussion: first, the voice was booming, and discipline was Poor. Second, there is violence in the competition to be the group leader. (T1)

In this class, disharmony within the group was highly prominent, even when There was no consensus on the product launch stage. Future teaching Activities should emphasize teamwork. (T5)

Another problem with small groups is that members do not participate in the work such as:

Today, the order of the group discussion was poor because there was no emphasis on the leader. The group leader could not control the group members, and some children did not have two classes. Participating in the classroom. (T1)

Select speakers and note-takers for a three-minute group discussion. It's important, but there's still the phenomenon that people are not involved in the group. (T3)

Another problem is that group activities are challenging to follow the division of labor within the group line, such as:

The group leader assigned tasks during group discussions, but the group members did not listen. Group leaders also do everything from start to finish by themselves and don't let Others intervene. (T1)

Teachers put forward strategies and suggestions to guide group cooperation, constantly Emphasize the sense of group cooperation, and propose multiple tasks for each team member. Games like competitions Stimulate a collective sense of honor, etc.

Teacher professional development: In professional development, teachers have diverse views. Teachers often lack an understanding of STEM concepts, and teaching materials were mentioned Enough. The understanding of the textbook content is not deep and thorough; the content of each Part arrangement is not coherent, logical, etc.

The course has many complicated knowledge points, and the logic is not strong, so the explanation of When part of the knowledge point can be adjusted to the absolute position and the time arrangement. (T2)

Another glaring problem is the teachers' lack of insight into STEM. Thorough understanding or understanding is shallow, resulting in the lecture is not in-depth enough. The grasp of the key points of STEM teaching materials is not unified, resulting in corresponding Students also having different understandings of STEM, such as:

Various teachers give different classes, so the students are right. STEM courses also have uneven perceptions, thinking development, and outcomes. (T4)

Some teachers shared their theories on STEM in the teaching reflection. One of the highlights of STEM is cultivating students' core literacy; this process is mainly reflected through design, construction, and evaluation. Giving more time to students, oneself especially, plays a guiding role, with STEM should be distinguished from craft classes.

In addition, several teachers mentioned being aware of the main lines of STEM courses. The connection of each link achieves a clear idea and rationalizes the logic of the textbook content Relationship, grasping the key content according to the actual course, flexible Schedule content, and steps. At the same time, teachers also mentioned the importance of the "engineering design process," Taking it as the main course line and always prompting students to focus on problem-solving and what can be done to resolve them.

Evaluation: Teachers said that the evaluation criteria were not expressed to students Clearly, resulting in an unconvincing and unfair assessment. How to Some teachers suggested taking the teacher's side in evaluating students' wrong answers Face prompt, other students supplement and guide, and other methods. At the same time, many teachers suggested that group self-evaluation and reflection had a better effect, such as:

I asked them to reflect on the reasons in the group discussion, and the summary was an excellent position. In the other group discussions, I felt the kids had something to think about. It's a messy class, but most kids can handle it. It's difficult for a second grader to make a reflective summary. (T2)

In addition, teachers in the teaching process will encounter sudden, unexpected Cases, for example, where a student loses a drawing designed for the last class, may Not redraw the design, and does not follow the design drawing when building the model. Each other Imitation, the results are much the same: Play with experimental materials, teach Room computer system problems, cannot play the video; Students often have surprise brilliant ideas that the teacher does not know how to answer, etc.

4. Discussion

We believe the findings of this study contribute to the present literature on STEM teachers' unique challenges in their classroom experiences and how these factors influence their instructional practices and students' learning outcomes in Pakistan and other underdeveloped countries in the region.

Our lives, livelihoods, and how we relate to one another are on the verge of a technological revolution. A transformation of this magnitude, scope, and complexity has never been experienced before by humankind. One thing appears clear: no matter how it unfolds, the global polity, public and private, academia, and civil society must engage in an integrated and comprehensive response [62].

Understanding the challenges and obstacles involved in developing and implementing integrated STEM curricula and instruction is imperative in light of the growing interest in and relevance of integrated STEM education [63]. Teachers value STEM education, but they identify pedagogical, curriculum, structural, student, and assessment challenges as barriers [34]. STEM education has an important impact on the future development of students. Yes, it helps them to improve their independent thinking, cooperation, and problem-solving skills [64]; the professional level of STEM teachers is to reach this level, the key to goals. However, STEM teacher professional development is often insufficient to support effective STEM teaching [65]. Stahlman et al. [66] pointed out that teachers find it challenging to grasp the rhythm of the class, resulting in The teaching process is not smooth, Difficulty managing time, and knowing how to guide students to complete the task. Materials brought by students are not available for experiments, etc. The findings of our study are in line with those of previous research. Thus, the problem appears to be persistent over time. We have found no effective solutions or remedies to those previously addressed issues. With these findings in mind, policymakers and authorities should focus on resolving these unresolved challenges, also known as gray areas.

For STEM teachers, the mastery of content knowledge is critical. A regular exchange of experience is of significant help to teaching. Other studies have also reported similar results in the past [67,68]. Analyzing STEM teachers' reflections on after-school education, identify problems that new STEM teachers encounter in their teaching process, and put forward strategies and suggestions, mainly focusing on classroom teaching. Management, group work, teachers' awareness of STEM and evaluation Aspects, and summaries of the lessons learned from these aspects. Well-trained and qualified teachers should teach students to prepare them for the 21st century. In order to improve the quality of STEM education, authorities should train novice STEM teachers and include STEM education activities in teacher training.

Teaching management and classroom teaching are the two most mentioned by teachers. Regarding STEM education research and practice, this means that both sides. The study's conclusions can provide a reference for the content and focus of future STEM teacher training and improve the efficiency and effect of STEM teachers' pre-service training. At the same time, the Conclusions and recommendations of this study are also provided for incoming STEM teachers valuable lessons to learn [69,70].

In terms of teaching management, teachers should accumulate and maintain classroom order to encourage and mobilize all students to actively participate in the class—teachers' Regular communication of teaching and research experience to improve professional teaching skills [71]. In order to develop positive STEM perceptions, educators need to work with students through a problem-solving framework. Problem-solving and project-based frameworks can increase learning motivation and improve student interest, achievement, and persistence, according to the STEM Task Force Report [72]. Opportunities to participate in authentic STEM learning experiences are crucial to developing positive STEM perceptions among underrepresented students.

As Ref. [73] argued, in classroom management, students can learn about everything a teacher does to organize students, time, space, and materials to facilitate student learning. Developing appropriate behavior patterns requires students to perform at their maximum potential. Effective classroom management strategies enable teachers to handle unexpected events and control student behavior. All teachers should strive to manage their classrooms effectively and create a positive classroom climate.

In classroom teaching, teachers should manage and distribute effectively. During class time, assign clear, specific tasks and try to make them into a Task list. Be familiar with the

lecture content before class and plan the content of each part—the connection between them. If experiments are involved, teachers should be prepared in advance with suitable and sufficient experimental materials and the requirements for experimental materials. Give instructions (such as using uniform experimental materials) and remind students to follow the design drawings.

As Ref. [73] pointed out, managing students' behavior may be the most challenging aspect of teaching for many beginning teachers. Due to faulty classroom management skills, it takes a teacher more time to correct misbehavior, lowering academic engagement. In order to effectively manage a classroom, educational expectations must be communicated, and a learning environment must be created.

In terms of group cooperation, teachers should cultivate students' teamwork spirit, knowledge, and cooperation literacy, guide the group to work together, and coordinate the spear within the group. All team members are encouraged to participate. In terms of professional development, teachers should be aware of the content of STEM textbooks and thoroughly understand STEM through pre-service training. Read the understanding and emphasis on the engineering design process. In terms of evaluation, teachers should clearly explain the evaluation criteria. To ensure that the appraisal is fair and believable, encourage the team to evaluate the appraisal. Reflection. Since this study is qualitative, there should be further quantitative analysis and in-depth interviews, followed by the further development of STEM teaching.

5. Conclusions

The study examines STEM teachers' unique classroom challenges and how they affect their instructional practices and students' learning outcomes. Many factors may contribute to the underdevelopment of STEM education in Pakistan. Researchers and educators in Pakistan might not understand STEM education's significance, contributing to this decline. The reason may also be that STEM education in Pakistan faces several challenges. These challenges include a lack of educational competency among STEM teachers, a poor curriculum, and insufficient student activities. Despite announcing new STEM schools, Pakistan's government has not yet implemented the program [13].

6. Limitation & Implication

To be able to define the limits of research, we must take into consideration many factors that we cannot control or identify for many reasons, among them are the following:

1. STEM teachers' dispositions, interests, and motivations.
2. For results to be transferable to other ages, many subjects must be piloted to ensure they are not limited to a small group of STEM teachers.

The school can develop its STEM curriculum based on the identified strengths and the obtained products. Additionally, understanding the challenges or barriers that affect the teaching-learning process from the perspective of novice STEM teachers can assist in addressing these barriers. Investing in infrastructure, matching specialization with tasks, and promoting a balance between education marketization and quality can address challenges STEM teachers identify at the microsystem and exosystem levels. These measures may create a conducive teaching environment. Overall, the research findings in this paper provide preliminary guidelines for future STEM discipline development.

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