

ELEMENTARY SCHOOL TEACHERS' PERCEPTIONS OF STEAM EDUCATION: A QUALITATIVE CASE STUDY OF SUKKUR, PAKISTAN

Muhammad Aslam^{*1}, Sayed Tanveer Ahmed Shah²

^{*1}lashariaslamshahin@gmail.com ²tanveer.ahmed@iba-suk.edu.pk

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Corresponding Author: *

Muhammad Aslam

Abstract

STEAM is a transformative pedagogical approach that fosters students' higher-order thinking skills to meet the demands of the 21st-century and global workforce. However, limited research has explored the teachers' perceptions of STEAM in low-resource contexts. This qualitative exploratory case study examined elementary teachers' perceptions of the STEAM integration. Seven elementary teachers were purposively selected, and semi-structured interviews were conducted to collect personal, in-depth, and context-rich data. Results revealed that teachers have positive perceptions of STEAM and that it improves students' conceptual understanding, PBL, critical thinking, creativity, and collaboration skills. However, barriers like a lack of resources, proper context, and subject-specific PD, as well as structural barriers, hinder STEAM integration. To overcome those challenges, teachers revealed strategies that include STEAM PD, provision of resources, structural transformation, i.e., allocating proper STEAM classes, and teachers' collaboration on STEAM activities. This study contributes to research on context-specific STEAM and highlights the need for contextual PD and structural transformation in low-resource settings. This study is recommended to stakeholders for funds allocation to schools, policymakers to transform the curriculum with project-based assessment and integrate activities in the curriculum, and teachers to collaborate on projects and cross-subject topics.

1. INTRODUCTION

In the early 2000s, the National Science Foundation in the USA initiated the Science, Technology, Engineering, and Mathematics (STEM) program to strengthen development and attract and train students for the global workforce (Milara & Orduña, 2024). Several programs were created after that moment to build the foundation of teachers, introducing pedagogies, developing curriculum programs, and addressing issues of STEM education. The NSF viewed it as an integrative approach and argued that it should be taught as a whole, not separately, bringing technology and engineering designs together with inquiry learning approaches. For example, instead of teaching separate concepts about energy, technology, and sustainability, students can design a wind

turbine that will include all similar information. Later on, to promote imagination-thinking beyond the text and innovative skills, STEAM was introduced as a pedagogical alternative (Abbas et al., 2024). It further discussed that STEAM is the way forward for developing skills to face the global workplace challenges that are captured under the 21st-century 4Cs, including creativity, communication, critical thinking, and collaboration.

According to Laksmiwati et al (2025), STEAM provides an opportunity for students to connect their arts knowledge to their learning, making it a contextual and culturally rich experience (Institute for Arts Integration and STEAM, 2021). STEAM is interdisciplinary in approach, which fosters creative and problem-solving skills to meet the digital world demands. It integrates

different disciplines to improve critical thinking and students' content knowledge, building a holistic understanding of the concepts and real-world applications (Liu, 2024). Teachers has potential to create a dynamic classroom learning environment enabling learners to learn smoothly as well as develop 21st-century skills using STEAM education (Hashmi, 2024; Tavgiridze et al., 2024). According to Buriro et al. (2023), it is important to reanalyse teaching criteria to foster STEAM, as teaching pedagogies foster consciousness in classrooms and help students learn effectively.

The World Economic Forum (2025) has emphasized STEAM Skills, expecting technological skills to grow more rapidly than other skills in the future, highlighting that employees' basic skills will change 39% by 2030 with technological skills. It shows the demand for these skills, and teachers can help students develop such skills to face the advancements. STEAM-integrated education is an effective pedagogy for developing such skills (Chansaengsee, 2024). However, many factors hinder STEAM integration, including low teacher training, lack of updated teaching methods, culture and context of the country, lack of STEAM-related curriculum and policy, and lack of collaboration between industries to integrate STEAM education. In Pakistan, STEAM is an emerging concept, and it has gained significant prevalence, but quality education is a major concern in Pakistan due to the lack of policies. Consequently, STEAM integration is affected as Pakistan lacks proper labs for science and technology (Hali et al., 2021).

1.1. PROBLEM STATEMENT

In 2019, the Asian Development Bank highlighted that Pakistan faces a significant gap in STEAM skills, as only 16% of students graduated in these fields. STEAM education develops students' creativity, innovation, and scientific and technological skills. However, it requires well-trained teachers (Hormazabal & Alsina, 2023). The Pakistani government has taken the initiative of STEAM Pakistan to improve STEAM education in Pakistan by building STEAM labs and providing resources. It integrates STEAM education in government schools, focusing on scientific and activity-based

learning, governance, and teachers' capacity building and support to transform students' STEAM learning. However, STEAM Pakistan lacks information on schoolteachers' knowledge and perception regarding STEAM Education.

Moreover, there is limited research on the teachers' perceptions of STEAM education at the elementary level. Further research can be conducted on the perceptions of the school educators, their philosophy of understanding STEAM, and what role they play in implementing STEAM education (Moon, 2020; Zimmerman, 2016). Therefore, this research explored the perceptions of elementary teachers towards the integration of STEAM in education to fill the gap in research about elementary teachers' perceptions of STEAM.

1.2. RESEARCH OBJECTIVES

1. To explore the perception of elementary teachers towards STEAM in education.
2. To explore the challenges elementary teachers face in the integration of STEAM.
3. To explore the possible solution(s)/mitigating strategies used/followed by Elementary teachers for STEAM integration.

1.3. RESEARCH QUESTIONS

1. What are the elementary teachers' perceptions of STEAM integration?
2. What challenges do elementary teachers face in the integration of STEAM?
3. What are the possible solutions(s)/mitigating strategies used/followed by Elementary teachers for STEAM integration?

2. LITERATURE REVIEW

2.1. STEAM as an Interdisciplinary Approach

The STEAM approach equally focuses on science, technology, engineering, the arts, and mathematics, making it interdisciplinary (Herro & Quigley, 2017). Its design and thinking process are grounded in the idea of authentic problem-solving and experiential learning (Henriksen, 2017). Additionally, art promotes creativity, autonomy, engagement, and most importantly, it creates a favourable environment for learning. In the beginning, the arts were not included; later, the "Rhode Island School of Design" introduced an arts component to STEM, providing students with relevant lessons to develop their problem-solving skills (Douthit,

2021). STEAM supports communication and collaboration, helping in retention and knowledge application in a novel environment (Liao, 2016). Moreover, it focuses on the learner-centred approach, especially problem-solving and inquiry learning approaches, and the changing role of the teacher as facilitator (Thibaut et al., 2018).

According to Herro and Quigley's (2016) study, arts integration in learning approaches like inquiry-based and PBL enhances creativity and critical thinking skills. The study informed growing research on STEAM integration and its use as an interdisciplinary learning approach in math and science classes at middle school to explore STEAM practices. Furthermore, a study by Lopez (2023) on teachers' and headmasters' perceptions of STEAM found that it motivates students to think critically, encourages collaboration among disabled persons, and enhances their social skills and self-awareness. PBL-based work promotes collaboration and eventually impacts the students' academic excellence. It advances students' reading skills and writing through learner-centred approaches and can help children choose their path to advance their skills. It highlights that STEAM is meaningful and inclusive, which is used to solve real-life problems and create engaging lessons, allowing students to collaborate, build their interests, and develop 21st-century skills (Firmansyah & Aslan, 2025; Wised & Inthanon, 2024).

2.2. STEAM and Teacher Professional Development

Teachers' STEAM professional development increased their understanding of teaching different content. According to Herro and Quigley (2017), STEAM PD is an initial but effective step to transform the teachers' practices. The study implications suggest that for successful STEAM teaching, PD in STEAM is necessary, and therefore, it should be promoted systematically and developed appropriately. Another study by Sias et al. (2016) analysed the lesson plans generated by teachers, and it argues that lesson plans generated by teachers can be a critical part of reflection to think about educational change and instructional choices of teachers. Further, analysis of the lesson plans showed that a moderate level of innovation is

considered by teachers. Teachers need support and more PD opportunities to prepare lessons with technology for the students' future. Further study suggests that the association between frequently and rarely used technology should be explored for further research. Additionally, sustained PD is important for STEAM integration (Hamad, 2022; Lopez, 2023).

Hamad (2022) introduces coherence of curriculum as a critical layer for innovation and stresses that professional development should address both pedagogical and content-specific weaknesses and consider it a gap in the expertise of teachers, like the integration of STEAM. Although this contradicts Sias et al.'s (2016) findings that, for innovation, existing methods are sufficient but highlights foundational skills and familiarity with innovation. Further, the study of Lopez (2023) revealed that various PD components of training assisted teachers in STEAM implementation despite many challenges adding that PD benefits teachers and instructors in science, technology, engineering, arts, and mathematics integration while teaching. Study also found that students who learned through STEAM performed better on the science benchmark exams, highlighting that STEAM training of teachers improves students' performance.

2.3. School Administrator Role in STEAM Integration

School administrators have a critical role in promoting the STEAM integration at institutions, and their role impacts school culture, teacher leadership, and system transformation (Douthit, 2021). Research emphasizes that administrators' role is not limited to the managerial responsibilities, but to support a child-centred approach in teaching, creating institutional collaboration, and sharing roles to build capacity for mutual responsibility for innovation in education. According to Hammad and Khan (2020), school headteachers need to focus on the importance of STEAM in schools, but they are neglecting it by not implementing it in classrooms. Further, Geesa et al. (2022) argues that administrators are the designers of the organization, and they are required to transform the traditional teaching methods to create a space for STEAM. Douthit (2021) suggests that leaders and administrators

can incorporate innovation, project-based learning, and collaborations to support STEAM. While Grillo (2018) argues that principals encourage PD of teachers and maintain curriculum standards. However, teachers and communities focus resources and materials and overlook the pedagogical shifts.

Additionally, as suggested in Grillo's (2018) study, leadership provides a top-down approach and ignores the discussion on resource differences and uncertainty, which limits the applicability of findings. Authority sharing by administrators to principals, teacher coordinators, and assistants for equitable integration of STEAM is the main component of the discussion. Saniha and Hanuscin (2017) stress for shared leadership that improves the confidence of teachers for change and long-term sustainability. Floreal (2019) also supports that successful implementation of technology, coaching within a structured support system is crucial. But these studies have neglected the systemic challenges and time constraints for professional development.

2.4. Teachers' Perception of STEAM Education

STEM perceptions of teachers vary according to their previous experiences. A study by Hamad, (2022) on the teachers' perception found that teachers were not confident in integrating STEM and expressed the need for hands-on training and PD workshops. Further, study highlighted that teachers lack the needed support, guidance, time, and leadership for the successful STEM integration. However, findings suggest that teachers perceived it differently due to their previous experiences, and results show that teachers cannot teach by integrating STEM due to the nonexistence of leadership support for its integration. Another study by Fong (2019) explored the attitudes of teachers towards the integration of STEAM and its importance in today's time. The study found that teachers showed a positive attitude towards STEM career discussions and highlighted that STEAM provides teachers a channel for the transfer of knowledge and connects them with their students by reflecting on their previous experiences. It shows that teachers' previous experiences play a vital role in perceiving STEM, and educators should be involved in the STEM

career discussion for learning different ways of integrating STEM.

Moreover, study by Lopez (2023) on the 'teachers and administrators' attitudes toward STEM education' found that all the participants had a positive, varied, and meaningful understanding of STEAM perceptions and they discussed how STEAM is combining 'science, technology, engineering, arts and mathematics' for engaging, and interactive teaching in the 21st century and improving skills needed for 21st century by combining multiple theories like multiple intelligence theory by Howard Gardner, Zone of proximal development by Vygotsky, framework for twenty first century and change theory. Results of the study shows STEAM increases collaboration among students for PBL to work in groups, boosting students' academic success. Moreover, the study argues that STEAM is an inquiry-based and interdisciplinary that blends several fields and prepares students for different roles, and helps them with rich, cultural, and relevant learning experiences.

2.5. Challenges Faced by Teachers in STEAM Integration

STEM is limited to mathematics or science, which is the real issue in many contexts. Teachers try to connect STEM with either science or mathematics, but not with engineering and technology (Herro & Quigley, 2017). According to study, STEM should not be context-based; rather, it should be connected to real-life situations and global challenges addressed by STEM. Herro and Quigley (2017), argue that STEM will face challenges until STEM, its PD, and assessment units are integrated into institutions with the help of policy and administration. Additionally, the interest of teachers and students is growing, but STEM lacks research on the characteristics that support this interdisciplinary approach for effective teaching and learning. However, teachers and school leaders recognized different barriers during the implementation of STEAM. These barriers include: no time for STEAM activities, resource lack, absence of vision and mission for STEAM, insufficient teachers' professional development in STEAM, and lack of frameworks and curriculum for STEM (Hamad, 2022). To address STEM challenges,

Long et al. (2017) emphasizes that stakeholders should have knowledge of STEM and its importance along with teacher leadership and teacher professional development for the successful implementation of STEM.

Additionally, major barriers found in the Lopez's (2023) study are funding for STEAM implementation, resources, time allocation, and PD. Study argues that it would be difficult to train STEAM teachers in all areas, but PD increases teachers' STEAM awareness and understanding. It highlights that central administration support is lacking in institutions, and rigid routines and curricular activities restrict the STEAM implementation. Moreover, study emphasize that stakeholders must initiate a formal piece of training on the STEAM recommending that STEAM goals, activities, and how they affect the students' success and \ teachers' pedagogy can be explored further. Furthermore, Abbas et al. (2024) and Silva-Hormazábal et al. (2023) identified the institutional limitations, lack of resources, and insufficient teacher knowledge as barriers to the implementation of STEAM in both Pakistan and Chile. Both studies focus on policy decisions and teacher training for the improvement of STEAM implementation. Another study by Ali et al. (2023) identifies that teachers don't have adequate STEM pedagogy, and this should be addressed through ongoing professional development, whereas Arpacı et al. (2023) highlight gender differences in STEAM efficacy and call for equitable pedagogical changes in the STEAM integration. Sahito and Wassan, (2024) literature review of 78 studies supports the challenges discussed above and asks for an updated curriculum and training opportunities for teachers to enhance their 21st-century skills. Literature review suggests that STEAM is an opportunity for teachers to overcome the obstacles students face in their learning.

3. RESEARCH METHODOLOGY

3.1. Research Design

This study explored the perceptions of elementary teachers towards the integration of STEAM education at Sukkur where STEAM workshops and seminar have been organized for instructors to improve their STEAM understanding and exhibition has been held to

develop students' interest in STEAM. This study could increase educational stakeholders' (teachers) knowledge of how to integrate STEAM, improving their understanding of challenges and strategies to overcome. The results of this study may be used in building the capacity of practicing teachers for STEAM (Zimmerman, 2016).

Qualitative research was selected for this study considering its holistic nature. Qualitative research is used to understand the different factors of a situation, creating a sketch from the larger picture, identifying and understanding the interactions between various factors in the situation (Creswell, 2013). Further, qualitative research aims to explore deep contextual meanings, focusing on voices and interpretations over numbers and figures, and developing new meanings, prioritizing in-depth exploration and perspectives of participants. Therefore, the chosen research methodology for exploring elementary teachers' perceptions towards the integration of STEAM in education is qualitative. Study employed exploratory case study design. Case studies focus on the process and explore situations and contextual environments in which researchers don't have clear outcomes. Yin (2009) defines that case studies provide rich, in-depth, detailed information, and it is primarily where the initiative has been taken. It informs the initiatives and programs with knowledge and strategies to follow. STEAM integration in the context of Sukkur is relatively new and lacks a single, clear set of outcomes. The phenomenon of this research study is how educators (teachers) perceive the integration of STEAM. Therefore, this case study design best suits my qualitative research study, "Perceptions of elementary teachers towards the integration of STEAM education."

3.2. Population and Sampling Method.

In qualitative research as given by Creswell (2013), the participants' selection is grounded on the idea whether participants will provide the deep, detailed and rich information and understanding for the research questions of the study and the study being conducted. The study's population includes teachers from the IBA Public School, Sukkur which has teachers from Kindergarten to Higher Secondary,

working to integrate STEAM in classrooms. The purposive sampling was used to select teachers because this study focuses on specific participants from the population, i.e., elementary teachers from IBA Public School, Sukkur. Further, this study is based on perceptions of STEAM integrations, which are not implemented in many schools. Additionally, purposive sampling helps researchers select contributors who can bring rich, in-depth, and detailed perceptions to the research questions. Participants were selected who had at least 3 years of experience in teaching at school, had knowledge about the concept of STEAM education, showed readiness to share their perceptions, and could provide insights on STEAM integration challenges and mitigation strategies. This study includes seven participants: two teach science, two teach math, one teaches English, and two teach social studies at school. Confidentiality of the participants was managed by sharing the research question before the interview, and a physical or online meeting was planned according to participants' convenience.

3.3. Data Collection Tool

This study collected data from elementary teachers through interviews for rich and detailed in-depth information regarding the perceptions, challenges, and mitigation strategies of implementing STEAM. For gathering data on personal narratives, perceptions, opinions, and experiences, interviews are considered best (Yin, 2009). Also, the qualitative interviews reveal the facts and meaning level of the participants. For reliability of the interview protocol, a protocol for interview refinement was employed (Castillo-Montoya, 2016). The research questions were derived from theoretical frameworks and existing research and were piloted with 2 individuals having characteristics like the study's sample, though they are not included in the sample. Participants offered feedback in the piloting phase on the clarity, composition, and comprehensibility of the questions. Before the data collection, improvements to the interview protocol were documented and applied.

3.4. Data Collection

Before data collection, approval was obtained from the principal for communication and interview scheduling with ETs. Th Email

addresses and WhatsApp numbers of the participants were compiled and they were contacted, and a consent form was shared with the participants. Those who agreed and shared back the participation form were interviewed. The semi-structured interviews were conducted by maintaining participants' confidentiality, ensuring only the participant and researcher presence, and interview was recorded. To explore perceptions of ETs, open-ended questions were included in the semi-structured interviews. A transcribed copy of the interview was shared with participants for member checking, as Yin (2009) emphasized establishing and adhering to a protocol, as well as formulating questions in an unbiased manner.

3.5. Analysis of the Data

Analysis of data in case studies is done through examination, categorization, tabulation, testing, or recombination of evidence to yield analytical observation-based findings (Yin, 2009). Novice researchers identify patterns, new concepts, and different themes by engaging with their data, as a case study lacks a definitive step-by-step analysis process (Yin, 2009). The interview was conducted at a place where both participants and the researcher were convenient. For the accuracy of the data, the researcher reviewed each transcript by replaying the audio recording of the interview a minimum of three times. For tracking codes and themes, the data were analysed following the six-step model of Braun and Clarke (2006) for thematic analysis: familiarization with data, generating codes, searching for themes, reviewing it, naming and defining themes, and writing up the report. For data analysis, though it is a structural but flexible method to generate themes that help researchers to get richness and depth of the data through interpretations rather than descriptions (Ahmed et al., 2025). Data was manually transcribed, and to identify concepts and categories about perceptions of STEAM integration, open coding was employed through multiple readings, aiming to generate a comprehensive set of codes from the data. Codes were organized into categories/themes. The data pertinent to each possible theme were collected and verified against the coded citations and the entire dataset. A further data analysis was conducted for supplementary themes. The researcher

engaged in iterative reading to identify themes until no additional themes were discerned.

Data confidentiality was protected and maintained throughout the study, kept in a password-protected file, and participants' folders were organized by giving assumed names and data types to differentiate between various data sources. It not only helped in the organization of the data but also improved the confidentiality of the participants' data and access to the data.

4. RESULTS, FINDINGS, AND DISCUSSION

4.1. Results and Findings

The findings of the study, perceptions of elementary teachers towards the integration of STEAM in education, include:

1. Teachers have positive perceptions of STEAM in education and are motivated to integrate it into the classroom.
2. ESTs acknowledge that STEAM benefits students by improving 21st-century skills, and it helps students improve academic performance.
3. ESTs face a variety of challenges and barriers to integrating STEAM education. It includes resources and time constraints, structural barriers, and limited professional development opportunities for teachers.
4. Teachers are confident in using low-cost materials for STEAM activities, but they lack proper guidance for the projects.
5. Teachers struggle to collaborate on the cross-subject topics for the understanding of the students, but limited time is another challenge for students.
6. Findings suggest that structural transformation, professional development of teachers, engagement of stakeholders, collaborative frameworks, and establishment of labs are a possible solution to the challenges/barriers.
7. STEAM activities shift students' rote learning to conceptual and practical learning, helping to make sense of the world.

The perception of elementary teachers towards STEAM education can be viewed below. These perceptions, after analysis, have been categorized into 4 major themes, which are STEAM perceptions, barriers/challenges to STEAM, possible solutions, and the need for professional development.

Thematic Code 1. STEAM Perceptions

The findings of the data indicate that teachers' varied perceptions of STEAM education. Most of the teachers defined STEAM as an interdisciplinary approach, while others defined it as a pedagogical approach, considering STEAM as a pedagogy to teaching that helps teachers to teach different concepts/areas in one class. The teacher shared the benefits of STEAM according to their exposure and experience with STEAM activities and participation in different activities. Theory of Vygotsky's constructivism states that individuals learn from their experiences and create meanings. Participants' views show how they have perceived or constructed their perception of STEAM education. Moreover, culturally responsive pedagogy discusses how teachers bring cultural understandings to the teaching and how they perceive students and what strategies will impact the student learning outcomes (Hammond & Jackson, 2015). Teachers' perception of STEAM is a part of the strategies they implement in their instructional practices. All the participants have different definitions, and some defined it as "STEAM is not a new idea, because we have already science, math, technology, and arts, but now we have to interconnect all those areas".

1.1. STEAM Definition and Its Purpose

STEAM is a learning approach that involves project-based learning and group work. It is the practical learning approach that shifts understanding to application in the real world and solves problems. After data analysis, the common definition used by participants is that it is an interdisciplinary method that combines STEM and the Arts. Participant B#6 defined it as "life is itself interdisciplinary, and to understand it, we need to learn through an interdisciplinary approach. Participant I#3 defined it as "STEAM is a transformational interdisciplinary approach because it transforms teaching methodology and traditional learning." The purpose of STEAM education is to eliminate rote memorization and build conceptual understanding. It focuses on 21st-century Skills development like creativity, communication, collaboration, and critical thinking. Participant S#1 shared that "It eliminates rote memorization and improves the quality of education by focusing on higher-order

thinking in the child and developing twenty-first-century skills, like: that children should be innovative, creative, and develop 21 twenty-first-century skills.”

1.2. STEAM Benefits

The biggest advantage of STEAM is that it nurtures higher-order thinking abilities, innovation, and creativity among students. They will be able to connect their knowledge to real-world circumstances and will retain information for longer. Moreover, it promotes gender equity and inclusive education for children. Moreover, STEAM engages students in activities and projects while developing students' confidence while presenting projects to the audience, and in class. Participant I#3 shared this as “STEAM through projects, shifts students' low-order thinking skills to higher-order thinking”. Further, participant I#3 added that “It can help students in developing interaction with peers, learn in groups, grow collectively, and it helps students to build their confidence in learning different concepts. Umm, STEAM benefits students to learn life skills needed for the global workforce”.

1.3. Relevance of the subjects

It was revealed from the data analysis that STEAM focuses only on science and math subjects, but especially in science, maybe it is because STEAM is naturally aligned with science due to its project-based nature. Science focuses on experiments, and it has a lot of projects to deal with, and STEAM also focuses on project-based learning and experiments. Art is neglected. Participants H#4, English, and B#6, social studies, stated that they are uncertain about the STEAM integration in the Arts subjects. Participant H#4 asked during the interview, “Is STEAM only limited to science? We, arts teachers, need knowledge for the STEAM integration in the arts subjects”. It shows that while integration of STEAM education, teachers are uncertain about it, and arts subjects are considered non-relevant to the activities.

Thematic Code 2. Barriers/Challenges to STEAM education

Teacher faces a lot of challenges while integrating STEAM education. Despite their

different experiences, most of the teachers face similar challenges due to the same context or culture. According to Hammond and Jackson (2015), culturally relevant pedagogy shifts the teachers' decisions of instruction. Moreover, STEAM education changes teachers' roles from teacher-centred to student-centred. These shifts create challenges for all to integrate STEAM. Teachers and stakeholders face similar challenges, like a lack of resources, funding, and PD opportunities for STEAM integration. Moreover, teachers' collaboration on the projects, exam pressure, and syllabus focus and exam-oriented culture at schools create a barrier to STEAM education. These challenges need to be considered for the integration of STEAM.

2.1. Limited Resources

Analysis showed that teachers face a lack of resources for STEAM education. Although resources are a basic condition for the activities. No material or proper kit and any lab is available at the school for these activities. Although there are labs in school like Physics, Chemistry, Biology, and ICT lab, these are for secondary and higher secondary classes. Participant S#1 said that “Teachers require materials for projects and materials require costs, and schools don't have a budget for STEAM-specific material. Providing timely material or resources to teachers for activities is a challenge.”

2.2. Structural Barriers

Participants highlight the structural barriers to STEAM education at their school. When asked do they integrate STEAM education, they responded with different structural challenges/barriers to STEAM integration. Participant B#5 said the “group activities take time and, in our school, and also in Sindh, class period time is 35 to 45 minutes, and it is not easy to manage activities in 40 minutes”. Additionally, other participants also stated that classrooms are overcrowded and they deal with exam-centred culture and pressure of completing the syllabus. Participant I#3 revealed that “It is impossible to do a STEAM activity or any related activity in a class of 40 minutes which have 45+ students”. Managing group work in an overcrowded classroom is a really great structural challenge that needs shifts from the traditional setup to updated classrooms and infrastructure.

2.3. Professional Challenges

Elementary teachers face professional barriers in the school. Data provided by the teachers shows that teachers are not provided training on emerging trends. Due to insufficient training opportunities and follow-up of the professional development teacher doesn't learn about the new trends. Also, teachers don't have enough time to collaborate with each other for professional learning and improvement. Participant B#5 argued that "School lacks PD for STEAM, and most of the senior teachers of the school still teach traditionally. He further added that the only reason behind this is the lack of training and PD sessions for teachers learning".

2.4. Management Problems

Management plays a vital role in implementing any new reform. Most of the school management follows a top-down approach, from giving orders or imposing something on the teacher to do. Analysis shows that teachers' efforts are not appreciated for STEAM activities, and there is no proper support for the teachers. Schools have leadership differences, like participant I#3 stated, "management asks for innovation but doesn't provide materials and resources for that innovation". Another participant, B#6, said, "Schools host events like STEAM exhibitions, STEAM Day, seminars, and workshops on STEAM just for photos, but in actuality, they don't change their school routines."

Thematic Code 3. Possible Solutions/Strategies

Participants suggested some possible solutions and strategies for the successful integration of STEAM education, including structural transformation, resource optimization, professional development of teachers, and stakeholders' engagement in school, including parents. Suggested strategies are discussed below with participants' views.

3.1. Structural Transformation

Data shows that a rigid timetable should be changed with flexible routines for STEAM implementation in classrooms. Most of the participants responded that they don't have time for the integration of STEAM. For example, participant S#1 shared the view "STEAM class should be included in the timetable once a week for each subject like science, mathematics, and

arts subjects, and STEAM labs should be built for activities". Participant H#4 urged, "Copy checking/worksheets assessment should be replaced by simple STEAM projects".

3.2. Optimization of Resources

Resource optimization is suggested by the participant. Analysis suggests grassroots solutions, such as the use of low-cost or recycled materials in the activities. Moreover, resource sharing among teachers is suggested. As said by Participant A#2, "I used low-cost/no-cost material in teaching activities, like I used cards and bottles for bridge building in the classroom, and also I collaborated with other teachers." Participant further added that although the material is low cost but it maximizes learning. Participant I#3 added "Teacher should share materials and resources for STEAM activities, like math materials, i.e., compasses and art paper, can be shared for the activity".

3.3. Professional Development Support

Sustained professional development can be a solution for developing teachers professionally. PD can be sustained with follow-up sessions, and a grade-wise road map can be provided to teachers for STEAM integration or activities in the teaching and learning process. Participant S#1 asked, "Management should provide grade-wise road map and lesson plans for STEAM activities". Participant I#4 asked for sustained PD, "Teachers should meet weekly to design activities and help each other, it could be sustained over time".

3.4. Engagement of Stakeholders

Participants argued for the stakeholder (parents and leaders) involvement in the projects and activities. Participant S#1 suggested, "Students' STEAM projects should be presented to parents, parents can take an interest in school events and support school for a better cause". Moreover, participants I#3 and B#6 argued, "Administration could reduce the workloads and buy in resources for teachers, especially fund labs for the STEAM education".

Thematic Code 4. Need for Professional Development

Several gaps have been found in the data, but the most critical and significant gap is the teachers'

support for reforms in the classroom. The findings show that very little attention is paid to the teacher's professional development in the schools for the STEAM integration. Most of the teachers shared they haven't attended any training or professional development workshop, but they worked on their self to learn more about the STEAM, its scope, and focus. Further, data shows that teachers developed a general understanding through the school events, but they are not confident enough to integrate STEAM because of a lack of PD opportunities, especially for STEAM.

4.1. Lack of Training Opportunities

Results show that the school lacks guidance for specific subjects. No subject-related pedagogy and guidance is available, especially for arts integration or for the arts class. Workshops and seminars are held after a long time, and no ongoing mentoring and guidance are provided. Participant H#4 argued, "How could I teach poetry, paragraphs, and writing focusing on STEAM? I know about the acronym STEAM, but I don't know about how to integrate it into my English subject". Participant further added, "Arts teachers are ignored for PD, only science and math teachers join PD. Another participant, B#5, stated, "One or two workshops are not enough for PD, we need sustained PD."

4.2. Collaborative Systems

According to participants, teachers want to collaborate, but they lack time. Participants ask for the teacher's teamwork. Participant I#3 argued, "The Teacher wants to work with other teachers, but they lack time". Therefore, a collaborative system is needed for the professional development and collaboration among the teachers. Participant B#6 urges, "Lesson study groups are followed in different countries like Japan, schools can promote lesson study groups for teachers' collaboration". Moreover, data suggests that cross-subjects time to plan for the activities of STEAM.

The data shows that the majority of teachers want to integrate STEAM activities in the classrooms, but due to different barriers like time, resources, and knowledge of STEAM hinder the teachers from integrating STEAM education. Management has to take the lead in the STEAM activities, focusing resources,

providing PD opportunities, and funding for STEAM activities.

The interview guide method was followed to collect the data. An interview questionnaire was provided to the teacher with open-ended questions before the interview. In an interview teacher, the teacher has to describe the experience and share perceptions related to STEAM, its challenges, and possible solutions to integrate STEAM in education. Semi-structured interviews were conducted, and a guide for interviews was created with a list of interview questions, which includes: How do you perceive STEAM education (your perceptions of STEAM education)? Do you integrate STEAM in your classroom? If yes, then at what level/topics/subjects do you employ this pedagogy? If not, then what are the causes/reasons/hindrances that halt STEAM Practice? Have you participated in any professional learning opportunities for STEAM integration at your school? If yes, was it helpful or not? If no, how would you discuss it? What are the major challenges you think of STEAM integration? What are the possible solutions (s) and mitigating strategies used/followed by you for STEAM integration? If STEAM is integrated/initiated at your school, what will be the benefits of it? And the last question was, do you want to share any additional thoughts, opinions, comments, or questions related to STEAM integration?

Additionally, to make participants feel at ease, a more casual interview was conducted to reduce the hesitation of the participants while sharing their experiences and opinions. Participants' provided data was grouped into themes focusing on the research question. The whole conversation was transcribed, including comments of the participants and examples for justifying their opinion.

4.2. Discussion

This study explored the perception of elementary teachers towards STEAM integration. The study found four interrelated categories/themes: STEAM Perceptions, Barriers/Challenges to STEAM education, Possible solutions/strategies, and Need for professional development. These themes respond to the research questions and contextualize the STEAM education realities in

a low-resource school in Pakistan Sukkur context, and they align with worldwide literature, highlighting context-based shades.

4.2.1. STEAM Perceptions (Research Question 1)

Most of the teachers perceived STEAM as an agent for the 21st-century skills development and emphasized its role in shifting from rote learning to conceptual and innovative learning, adding critical thinking and problem-solving skills. It eliminates rote learning and improves higher-order thinking skills and develops 21st-century skills of children to be innovative, creative, and problem solvers.

This relates to the international literature where STEAM is considered a “Transformative approach to learning” which fosters creativity, critical thinking, and cross-subject connections (Herro & Quigley, 2017; Lopez, 2023). But teachers have different perceptions due to their different subjects of teaching. Further, some participants considered STEAM as a pedagogy extension. While teaching geometry, computer and art teachers can collaborate for pedagogic shift because geometry is not just about math shapes, but it's art and technology integration. Moreover, some teachers of arts are not sure whether teaching English through dramas and paly is STEAM or not? This relates to the findings of Hamad (2022), that it creates an integration gap in the implementation when non-STEAM teachers are ignored while STEAM discourses and PDs are being implemented. Although arts subjects are part of STEAM but they are ignored in the discourses

4.2.2. Challenges/Barriers to STEAM education (Research Question 2)

The major hurdle highlighted by teachers is the scarcity of resources in the school. Almost 5/6 participants shared about the lack of resources, technology in school, and proper labs for STEAM work: School doesn't have a proper budget for STEAM kits and labs. How teacher could teach or integrate STEAM without technology in the class. A study by Abbas et al. (2024) in Pakistan also highlights that restrictions by institutions and limited funding are the main barriers to STEAM. Moreover, structural barriers like overcrowded classrooms and less time for class intensify the issue. These

findings align with the study of Silva-Hormazabal et al. (2023). It highlights that rigid curricula and large classrooms are barriers to project-based learning in the Global South.

Furthermore, in this digital era, administration is prioritizing the exams over projects. Additionally, the STEAM exhibition has become the trend, and STEAM exhibitions are often hosted symbolically without any sustained transformation. Although it sets the mindset for science activities and projects, it systematically resists change. This supports the findings of the study by Douthit (2021) that administrative vision determines the success of STEAM by focusing on teacher agency. Moreover, a lack of PD opportunities, especially for humanities teachers, hinders the teacher's preparation for STEAM integration. Arts teachers are ignored in PD opportunities, while science and math teachers are asked to join the PD sessions. This validates the finding of the study by Hamad (2022) that training deficits spread inequities for STEAM access.

4.2.3. Possible Solutions/Strategies (Research Question 3)

Study reports a structural shift and advocates for restructuring the timetable, adding 1 class of STEAM with 1 hour plus duration for STEAM projects. Moreover, resource optimization should be focused, like using cards and bottles for a physics project, building a bridge, and teachers can use low-cost materials to maximize learning. Innovations like emphasizing low-cost material to maximize learning in low-resource contexts align with the study of Herro and Quigley (2017).

Another strategy study suggests is that collaboration between different subject teachers, like English, Science, and ICT teachers, can collaborate on the topic of the solar system. The English teacher will suggest maintaining diaries and science for creating a project on the solar system, while the ICT teacher will help in technology provision. According to Sias et al.'s (2017) study, interdisciplinary planning of teachers fosters integration.

Findings of the study suggest sustained PD according to their subjects. Most of the workshops are organized generally for pedagogy and teaching methods, but in actuality, every subject teacher wants to know about how to

teach that specific subject, like English teachers is interested in how to teach English topics like poetry through STEAM. This aligns with the recommendation of Lopez (2023) for differentiated PD to address integration gaps among different disciplines.

4.3. Implications

4.3.1. Theoretical alignment

Data analysis reveals a gap in the teachers' pedagogical content knowledge (i.e., Participant H#4 stated, "I struggle to connect STEAM to my class being an English teacher"). It discloses the need for professional development focused on the TPACK framework (Mishra & Koehler, 2006). Moreover, administrative differences contrast with Douthit's (2021) model "Leaders as STEAM Architects".

4.3.2. Recommendations

Recommended to	Recommended Action
School Administration	It is recommended that school management and administration, and higher authorities should allocate budgets for STEAM resources, divide the overcrowded classroom into two or more sections, and set collaborative planning time for teachers.
Policy Makers	It is recommended that policymakers revise the curriculum and include project-based assessment in place of exam-oriented assessment, provide funds for STEAM labs in government schools, and provide PD opportunities to teachers.
Teacher	It is recommended that teachers develop STEAM-based lesson plans, collaborate in lesson study groups, and show readiness for the change (Participant B#6)

4.4. Limitations of the study and Further Research

The study has a small group of participants (N=7) and is an exploratory case study. It is limited to one school. Further action research can be conducted on the low-cost STEAM model in low-resource contexts. Additionally, time-to-time studies on the role of leadership in sustaining STEAM can be conducted to deepen understanding. Also, gender-based perceptions analysis and STEAM integration experiences can be explored (Arpaci et al., 2023)

5. CONCLUSION

STEAM education is not only a trend, but it is a pedagogically transformative approach to

learning that develops 21st-century skills, including communication, collaboration, critical thinking, and creativity. This study reveals that elementary teachers at IBA Public School, Sukkur recognize STEAM potential to transform learning from rote memorization to conceptual learning, including problem-solving and project-based learning. Teachers acknowledged that STEAM advances higher thinking skills, supports the creation of an inclusive environment, and links interdisciplinary knowledge to help students boost their confidence and retain knowledge through experiences.

Until now, this promise has been inhibited by systemic challenges. Structural barriers like

overcrowded classrooms, rigid school timetables, and a focus on exams rather than projects limit the opportunities for STEAM education. Lack of resources, including insufficient funding, lack of STEAM labs, and technology deficit, further hinders the transformative pedagogy. Along with these challenges, there is also a gap in the professional development of teachers where arts teachers are excluded from the STEAM training and PD opportunities while the science and math teachers lack subject-specific and sustained PD for implementation.

Despite many barriers, teachers showed strong motivation towards innovations and used low-cost materials in the classrooms, like cards, bottles, and other recycled objects for the projects, demonstrating teachers' agency to create learning opportunities. Teachers advocated for flexible timing, STEAM classes, and collaborative timing like professional learning communities, highlighting the path towards change. Significantly, they emphasized that science, English, and ICT teachers can co design solar system, making it interdisciplinary. For STEAM to be reality rather than aspiration, stakeholders have to act accordingly. School administration should assist teachers to collaborate, reduce class size, must allocate funds for the STEAM resources. Policy makers are working to update curriculum but one thing that exams should be replaced where necessary by the projects and STEAM labs should be build practical work. Although teachers can work in groups like lesson study groups and share resources to create STEAM activities.

Metaphor used by participant B#6, concludes the whole study; "Like Biryani ingredients, we have all STEAM ingredients, but what we need for cooking is water, fire, pot, and the recipe". Here recipe highlights the context specific PD while fire, water and pot demand for the resources for the integration of STEAM and its potential to rise.

This study is limited to Pakistan school Sindh context Sukkur but it emphasizes the universal issues of low resources settings school. Future research can be conducted on low-cost STEAM projects, leadership role in creating sustainable STEAM projects and reforms and genders impact. Teachers as change agents should be encouraged. By addressing gaps and promoting pedagogical knowledge through PD stakeholders

can help to foster innovation and academic success in this rapidly changing world.

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