ACADEMIA International Journal for Social Sciences
Volume 5, Issue 2, 2026 ISSN-L (Online): 3006-6638

# Exploring the Professional Development Needs of Public Elementary School Teachers for STEAM Education: A Qualitative Study in Sukkur, Sindh

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**Received:** 04-01-2026 **Revised:** 28-01-2026 **Accepted:** 16-02-2026 **Published:** 21-02-2026

## ABSTRACT

*In today's evolving education system STEAM (Science, Technology, Engineering, Arts, and mathematics) education has emerged as a key approach that enhances student's critical thinking and problem-solving skills. Implementation of (STEAM) education in elementary schools necessitates educators to hold not only specific pedagogy but also hone the set of interdisciplinary teaching skills which meets with the standard of STEAM education. Nevertheless, educators in public elementary schools in Sukkur, Sindh experience challenges in applying the concepts of STEAM. Owing to, lack of prospects in personal development, insufficient training courses, and the shortage of resources. This Qualitative research paper investigates how public elementary school teachers in Sukkur district understand STEAM education, identify the needs of professional development, and examine the challenges they face in implementing STEAM practices in classrooms. A purposive and a snowball sampling method were used to sample 25 teachers at public elementary schools in Sukkur. Semi-structured interviews were used to collect data and analyze it using thematic analysis. Results showed that teachers do not have the Sufficient information about STEAM pedagogy, not only the exposure to the technological integration but also leadership and management hardly support professional development. Teachers shared content knowledge improvement, practical training disclosed as the needs in teaching methods that cover interdisciplinary and mentorship programs. The study suggests that centers of professional development, context relevant STEAM training programs and learning communities amongst elementary teachers in Sukkur should be established.*

***Keywords:*** *STEAM Education, Professional Development, STEAM Pedagogy, Learning Communities, Elementary School Teachers*

## INTRODUCTION

Global education systems are undergoing fundamental transformation driven by technological advancements, globalization, and evolving workforce requirements. The 21st century requires learners to acquire critical thinking, creativity, collaboration and problem-solving skills that go beyond the conventional disciplinary lines (Partnership for 21st Century Learning, 2019). Therefore, educational reforms have increasingly focused on integrated approaches to teaching and learning, particularly with the use of STEAM education as an interdisciplinary model that combines science, technology, engineering,

arts, and mathematics (Suwarma & Kumano, 2019). STEAM education represents an evolution of STEM education by incorporating artistic and creative dimensions, thereby fostering innovation and design thinking among learners (Boy, 2013). The STEAM pedagogy guides students to solve real world issues using inquiry learning, experimentation and group projects that simulate real workplace procedures.

Advanced countries have widened scope both horizontally and vertically by investing in infrastructure of STEAM education on teacher training and curriculum development. The United States, Finland, Singapore, and South Korea are some of the countries that have established extensive frameworks of STEAM that include strong professional development systems that guide teachers. These countries have unveiled real potential of education for successful implementation of STEAM education; the teachers' strong content knowledge, pedagogical skills, and confidence to provide experience of interdisciplinary learning. As a result, teachers' professional development has emerged as the pillar of effective STEAM education change in such settings.

In public Elementary schools of Pakistan, there is very little focus on inquiry based-learning or interdisciplinary studies such as STEAM education. The classroom practices are mostly teacher centered based on rote memorization and preparation of exams (Batool, 2022). Most of the teachers have received training in only one discipline (Honey et al., 2014). Which does not align with the standards of STEAM education.

**Problem Statement**

STEAM education demands the teacher to horn specific skills that do not fall within the conventional subjects or academic subjects but rather encompass multidisciplinary approaches such as lesson planning and design, inquiry lesson facilitation, use of technologies, and construction of a collaborative learning environment (Shernoff et al., 2017). Such competencies are developed in the process of long-term professional development, which include the content knowledge, pedagogical training, and continuous support. Moreover, STEAM has very powerful effect when teachers have ongoing support (Thompson et al., 2018).

In Sukkur, Sindh, elementary teachers do not have sufficient knowledge about the STEAM as an integrated approach. Most of the teachers' view is on science, technology, engineering, arts, and mathematics as distinct subjects instead of interrelated fields. Such narrow conceptual knowledge makes it very challenging to implement STEAM education into the classrooms.

The teachers are provided with insufficient professional development regarding STEAM because the available training is based on traditional methodology with little exposure to integrated and inquiry-based training. Without mentorship plans or learning communities, the teachers are deprived of professional development in the STEAM pedagogy.

**Significance of Study**

This study is important for various stakeholders, policymakers, and education department officials within the education system of Pakistan because this study is expected to provide insights into teachers' knowledge and perceptions of STEAM education. This, in turn, may support more informed decision-making regarding resource allocation, the design of training programs, and policy formulation.

Studies show that STEAM-focused professional development can foster teachers' interest in implementing STEAM education (Dejaranette, 2018). Understanding how teachers conceptualize STEAM pedagogy, the types of support they perceive as necessary, and the obstacles they encounter may enable authorities to move beyond traditional professional development approaches toward more localized and context-sensitive interventions that reflect classroom realities.

For professional development facilitators, the study provides insights into teachers' current levels of understanding, competency gaps, and training priorities. These insights can inform curriculum development and program design. Identifying teachers' training and support could inform the facilitators to design the targeted Professional development Programs that are more likely to bring meaningful changes in classroom practices**.** Furthermore, understanding the challenges faced by teachers enables the inclusion of practical, contextually relevant strategies in STEAM training programs.

The study also highlights the challenges teachers face in implementing STEAM education, enabling school administrators and educational leaders in Sukkur to provide more effective institutional support, allocate resources efficiently, and create an enabling environment for pedagogical innovation.

**Research Objectives**

i. To explore the understanding of STEAM education among public elementary school teachers in Sukkur, Sindh.

ii. To recognize professional development needs of public elementary school teachers for effective STEAM education implementation.

iii. To analyze the challenges faced by teachers in implementing STEAM education in their classrooms.

**Research Questions**

i. What is the understanding of STEAM education among public elementary school teachers in Sukkur, Sindh?

ii. What kind of professional development do public elementary school teachers need for an effective STEAM education implementation?

iii. What challenges do elementary school teachers face in implementing STEAM education in their classrooms?

## LITERATURE REVIEW

### Evolution and Conceptualization of STEAM Education

The idea of integrated science, technology, engineering, and mathematics in education was first introduced in the early 90s when the National Science Foundation in the United States started advocating interdisciplinary ways of teaching science (Nzimande, 2023). Initially, known as STEM education, this method was designed to equip students with more technology driven work environments by deconstructing the subject boundaries. The innovation to add Arts to compose STEAM was later because it became clear that creativity and design thinking are important elements of innovation and problem-solving (Khairullina et al.,2022).

Recent research has narrowed the conceptualization of STEAM education. The study on the definition of STEAM in various countries revealed that there is significant diversity in the way teachers define and apply integrated teaching (de Souza & Milakis, 2025). This difference in interpretation poses problems in standard implementation and teacher training.

### Teachers' understanding and professional development for STEAM Education

A study on the awareness of teachers about STEAM education indicates that there is a lack of understanding of the subject, especially among elementary level teachers in public schools. In the study of

STEM integration among elementary teachers in the United States, Rinke et al. (2016) discovered that most of the teachers have a shallow idea of what integration entails. Wahono and Chang (2019) investigated the conceptual knowledge related to STEAM education of the elementary teachers in Indonesia and found out that many of the participants did not have clear conceptualizations regarding integrated teaching. This gap in understanding prohibited teachers from creating genuine STEAM learning opportunities even though they could access resources and materials (Amanbayeva, 2024).

Specifically, in Pakistan there is a lack of research on STEAM understanding of teachers. Nevertheless, Halai and Khan (2024) examined the pedagogical content knowledge of science teachers in Karachi, and discovered that teachers were largely traditional, teacher centered concepts of science education and had little knowledge about inquiry based or integrative teaching methods. Their work indicates that there might be some conceptual obstacles to the implementation of STEAM among Pakistani teachers, which cannot be reduced to the insufficiency of training.

The study by Herro et al. (2020) found that over time, teachers become more familiar with STEAM. After a year of professional development, the teachers were observed to have gradual changes in their view of STEAM. Park et al. (2016) examined the case of Korean teachers who went through intensive training programs in STEAM. They discovered that effective programs should interlink content knowledge building with pedagogical training and offer the possibility for teachers to design, implement, and reflect on STEAM lessons in their personal classroom. Those teachers who had been trained purely on theory without a chance of applying any practical application did not change much regarding their actual teaching practice (Donath et al., 2023). Those teachers who went through the experience of STEAM learning created better insights into the thinking and learning of students (Cooke, 2022).

Professional development in various contexts has been growing in importance, especially in the developing nations. Jita and Mokhele (2014) discovered that professional development models created in the western context had little success in meeting the local realities such as large classes, resource scarcity, curricula limitations. There is a need to come up with contextually relevant models that value and respond to certain obstacles teachers encounter in under-resourced environments (Lavicza et al., 2022). Furthermore, some recent studies have observed the development of teachers in understanding STEAM over time (Milakis, 2025).

**Challenges are STEAM Implementation in Developing Contexts**

According to Murphy et al. (2019) “the challenges prevalent in various countries and regions included poor infrastructure, lack of teaching resources, big classes, assessment stress, and the inflexible structure of curriculums and programs.” The combination of these challenges creates environments where STEAM teaching is extremely demanding no matter how the teachers are prepared. In Pakistan, Hoodbhoy (2009) reported that “A great range of defects in science education such as non-functional laboratories, old equipment, lack of funds on materials and supplies.”

Ejiwale (2013) reviewed the STEM education in third world countries and discovered that absence of laboratory facilities, technology infrastructure and simple teaching resources did not allow many teachers to engage in practical STEAM learning despite having the relevant knowledge and skills**.** The confidence of the teachers, along with their self-efficacy, has a serious impact on the implementation of STEAM (Jiang et al.,2024). Most teachers have no confidence in their capability to teach integrated content, especially the technology and engineering subjects where their own educational preparation was limited (Alanazi & Zahrani, 2025).

Curriculum constraint is also a significant barrier to implementation (Mitchell, 2024). Ritz and Fan (2015) investigated the effect of curriculum structures on STEAM implementation and discovered that

systems that rely on examinations provide a powerful deterrent to teachers to implement innovative strategies that cost them time to prepare students for exams. In Pakistan, Nayyar and Salim (2012) reported the examination pressure, overpower teaching practices and low chance of exploring or using integrated learning activities.

The access to professional development itself is a significant problem (Monkeviciene et al., 2020). There are probably similar obstacles in Sindh where teachers in Sukkur have less access to training centers and professional development opportunities (Soomro et al., 2025).

## RESEARCH METHODOLOGY

The proposed study utilizes the research design of qualitative research to determine the knowledge of the Public elementary teachers about STEAM education, their professional developmental requirements, and the difficulties encountered during their implementation. The choice of qualitative research was determined because the researcher can study complex phenomena in- depth, learn about the thoughts and personal experiences of the participants, and analyze the challenges in their natural settings (Creswell and Poth, 2018).

This study included all Public elementary school teachers employed in the districts of Sukkur region in Sindh. Moreover, 25 teachers through purposive and snowball sampling as a sufficient sample were selected to conduct the study referring to the principle of data saturation. Guest et al. (2006) discovered that in relatively homogeneous samples, saturation may be reached in the first 20 interviews, but 15-25 interviews are more assured.

The tool of data collection applied in this study was semi-structured interviews because it allows the researcher to ensure flexibility and help to explore the personal beliefs and insights of the participants. Semi structured interview protocol was formulated in accordance with research questions of the study. The protocol had three major sections that were in line with the three research objectives. The initial part of the interview consists of the questions that covered the understanding of the teachers about STEAM education. Additionally, the second part helped to identify the need and support for effective professional developments for STEAM education. The third part addressed the challenges in implantation of STEAM in education.

Public Elementary teachers were Selected on the basis of 3 to 6 years of teaching experience to make sure that they have sufficient teaching experience to make considerations about teaching practices and professional growth that are reflective, the sample covers both male and female teachers and represents gender diversity in the teaching profession. Further, the participants were made aware of the purpose of the study and procedure, and confidentiality was ensured by using pseudonyms, keeping information about the participants safe and secure.

This study incorporates relevant theoretical frameworks, including constructivism theory, TPACK Framework, and Desimone's model which collectively provide a foundation for STEAM Professional development.

- Constructivist learning theory is based on the concept that the learners construct knowledge through their experiences and not receive information passively (Piaget, 1954; Vygotsky, 1978). Teachers can learn best by applying the constructivist principles which encompass the ability to interact with new concepts, relate them with the knowledge already known and use them in real life situations (Fosnot & Perry, 2005).
- TPACK framework was created by Mishra and Koehler (2006) acknowledges that good teaching using technology demands the knowledge that are at the intersection of three areas namely: content knowledge (knowledge of the subject matter), pedagogical knowledge (knowledge of

instruction) and technological knowledge (knowledge of technology tools and applications). In the context of STEAM education, where technology integration will be inherent throughout various content areas, the TPACK framework will serve as a helpful tool in examining the needs of teachers in professional development.

- The Core Conceptual Framework of Professional Development developed by Desimone (2009), there is a pathway to this model in which these core features result in increased knowledge and skills in the teachers which alters classroom instruction eventually resulting in greater learning in the students. This model will be quite applicable to the STEAM professional development in Sukkur because it focuses on applied, extended, and interactive learning among educators.

**Data Analysis**

The collected data were transcribed and reviewed by the participants to ensure trustworthiness and accuracy after transcription the data were systematically analyzed using thematic analysis to identify emerging themes described by Braun and Clarke (2006). Thematic analysis helps to break down and discover the essential themes and patterns in Qualitative research. The process of analysis was carried out using six stages. At first the researchers were acquainted with data, rereading each transcript, listening to the recordings. Second, the researchers came up with initial codes by going through the entire dataset systematically to discover features and coding data in reference to research questions. Third, the researcher was searching using the criteria where the codes undergo sorting to identify potential themes and extracting all the corresponding coded data into each theme. Fourth, thematic review was conducted considering whether they functioned in connection with coded extracts, and to the whole dataset, and producing a thematic map of the analysis. Fifth, themes were established and labeled by clarifying the details of individual themes and coming up with clear definitions. Sixth, the final report was obtained as the researchers chose striking examples, connecting analysis with research questions and literature.

**RESULTS AND FINDINGS**

**Theme 01: Teachers Understanding about STEAM Education.**

The initial research question was the understanding of public elementary schools' teachers about the concept of STEAM education. The result of the analysis showed positive and worrying trends in terms of conceptual understanding of teachers.

It has been analyzed that the awareness among teachers regarding STEAM education was distributed according to a spectrum rather than being limited uniformly. Some teachers (5 out of 25) were found to be very limited but on the other hand, there were others who portrayed promising background knowledge which could be developed through professional development. The teachers who had difficulties in clearly defining STEAM education.

> "*I have heard this term STEAM somewhere, but I am not sure what it is" (P1). "STEAM is a new word to me" (P6).*

Nevertheless, a number of teachers (10 out of 15) proved to be moderately aware and showed true intentions to learn more. One of the teachers, having attended a workshop in Karachi mentioned

> *"STEAM was a combination of teaching science, technology, engineering, arts and mathematics as one lesson. This concept is quite interesting to me since it links subjects to each other in meaningful ways" (P5).*

This reaction demonstrates that the understanding level of awareness as well as appreciation of integrated solutions.

Surprisingly, some teachers (5 out of 15) had a rather strong intuitive grasp despite not having formal training in STEAM. As teacher Maryam clarified,

> *"I believe that STEAM is when the students are working on the real problem and they have to apply scientific knowledge, make some calculations, possibly create something, and make it creative. The subjects are not independent of each other. This renders learning more convenient and helpful to the children" (P7).*

There are also a number of teachers who saw links between STEAM and reality. One of the Teacher said,

> "*We do not apply science in our everyday life on its own, without the use of mathematics and technology. All is blended into one. STEAM is logical since it is mirrored in our real-life problem solving out of school. This is a practical knowledge that has a solid basis in the implementation of STEAM" (P10).*

Sequential teaching of subjects was also first characterized by some teachers and a teacher explained,

> *"I teach in STEAM-based lesson, I teach science topic, then I teach mathematics about that topic, then I use art to decorate. Each subject has its time; I believe the better way would then be when all subjects occur simultaneously through a single activity. I do not know exactly how I will do this, but I would like to know" (P15).*

Some of the teachers expressed advanced knowledge of genuine integration. It is found that the real STEAM is not about separating teaching on subjects. It entails the establishment of learning activities in which the students spontaneously make use of various subjects to address real issues.

**Theme 02: Professional Development Requirements identified by Teachers.**

The teachers showed excellent self-awareness regarding the gaps in their content knowledge and expressed definite learning requirements. Teacher clarified,

> *"I am not confident in technology and engineering. What these subjects are I need to know before I can impart them into children. My education was not in engineering or high technology. How can I apply technology into STEAM?" (P16, 20).*

Teachers demanded training that would assist them to get to know the concepts of STEAM at their own level and then they could seek to explain to the students. One of the teachers demonstrated that,

> *First, we teachers have to learn STEAM. We require training that we are learners and not merely received lesson plans to follow" (P22).*

Such request indicates the cognizance of the teachers that substantial implementation cannot be made without an in-depth grasp and not just a superficial acquaintance.

Educators were very emphatic that they needed practical, hands-on training and not theoretical lectures and they provided certain recommendations on what professional development would be effective. Teacher said,

> *"There are a lot of workshops that we go to, and they provide us with theory and PowerPoint presentations only. We require the training in which we practically do something and rehearse teaching techniques" (P17) Another Teacher responded, "Give us some real STEAM classes, we will see how it is done, we will learn under some supervision. Do not just tell us about it." (P10)*

Educators demanded training that contains demonstration lessons, the possibility to see model teaching, assistance during the creation of integrated lessons, and feedback about their efforts. Teacher clarified,

> *"I should get a glimpse of how STEAM lesson is like in elementary classroom with actual students. Then I must visit one by myself to do it with somebody working with me" (P12).*

The teachers were also creative in proposing training format that would fit in Sukkur context. Teacher suggested,

> *"Training would be in stages first workshop to introduce ideas, then we will give it a go in the classrooms, then we will gather up and discuss what has worked and what has not, then more training on the basis of our experiences" (P23).*

This recommendation reflects a complex knowledge of progressive professional growth.

Although teachers mentioned lack of resources as a major issue quite a few of them also displayed much ingenuity in thinking about how to work under limitations and make use of available resources. Teacher clarified,

> *"Training is of no use when we lack materials to use once we get back to classroom. Train us and also provide us with basic resources to begin with" (P11). Additionally, she said, "we would require low-cost materials that would be simple and are accessible in Sukkur. Do not present to us costly gear that we can never afford" (P25).*

Nevertheless, some of the teachers were very resourceful in their thought process. Teacher recommended,

> *"Most STEAM can be accomplished using items that are found in the everyday materials bottles, cardboard, strings, local plants, kitchen items. We should be trained in ways of utilizing these basic materials innovatively and not necessarily rely on costly machinery. Teacher added: In our communities, individuals address issues using scarce resources. This is the same resourcefulness that we can impart on children with the help of STEAM with materials our local surroundings" (P2).*

Technical assistance was also reported to be an essential requirement, yet teachers were aware that it could be handled using peer assistance. Another Teacher clarified,

> *It is impossible to ask anybody to help us when we attempt to use computer or projector and it fails. But when a few teachers learn together, we may assist one another in technical difficulties. Teacher added, "Perhaps there are good teachers who can become resource persons to others in their schools, on matters to do with technology" (P7).*

One of the most pronounced points that the teachers made was that one-time workshops are not enough to build the capacity of teaching STEAM, and they were very interested in establishing collaborative support systems. Teacher replied,

> *"We have a training day then we are on our own. We require somebody to coach us when we encounter difficulties in implementing what we were taught. Teacher told me the same, "On training there are various questions that arise when we finally attempt to teach. We require skilled ones on whom we can call" (P24).*

The teachers asked to create mentorship programs and learning communities in which the experienced educators of STEAM would be able to offer continuous guidance and monitoring of their instructions and feedback, as well as to solve problems in implementation. Teacher said,

> *"I want mentor that can come to my classroom and observe my lesson and tell me what to change. This would go a long way than workshop, a group of teachers' study STEAM, and help one another, it would be not complicated as when they start to study alone. Some of the teachers proposed the formation of teacher learning communities where teachers would exchange experiences, co plan, observe their teaching behavior, and collectively resolving the problems" (P1,7,9,12).*

A number of teachers suggested certain collaboration structures. Suggested by the teacher, the teachers in their local schools can meet once a month and share with each other what they did in STEAM activities, what worked, what did not work and how to improve them. This would be free but would offer continuous support. Another Teacher replied to this, saying that we can make WhatsApp group, in which teachers exchange ideas, ask questions, and send pictures of student work. In this manner we remain in touch.

**Theme 03: STEAM Education Implementation challenges**

The third research question studied the obstacles or problems encountered or expected by teachers in the use of STEAM education.

The challenge that was the most cited was resource and infrastructure limitations and all 15 teachers experienced it. Nevertheless, realistic problem-solving attitudes were displayed by the teachers and not merely complaining. According to a few teachers,

> *"We have no science lab, no computer, no internet, no simple equipment in our school, nonworking or minimum number of laboratories, lack of technology infrastructure, limited funds and unavailability of electricity. Without anything how will we do STEAM activities?" (P15, 11, 20, 23).*

Educators cited inflexible curriculum demands and test pressures as key implementation challenges, yet most also acknowledged that implementing change needed systemic changes and not individual teacher initiatives. According to Teacher Noor,

> *"I have to go through the required curriculum and get students ready to take exams. I cannot even attempt new approaches such as STEAM. Teachers elaborated on the same, our curriculum is extremely rigid. There is content that each subject has to cover. When will there be time to be in STEAM activities?" (P 6).*

Nonetheless, a number of teachers contemplated this difficulty. Teacher said,

> *"Parent and administrators assess teachers based on exam scores of students. Exams are used to assess memorized learning in books. In case I am involved in STEAM activities, students may not pass their exams, and it will be my fault. then she said, But I also know that true learning observes through the understanding and the practicing, but not through the memorization" (P 20).*

There are short answers and multiple-choice questions in elementary school exam system. However, STEAM apparently requires alternate evaluation, yet teachers are not aware of how to conduct it, and it is not enjoyed in the system. Education department could test STEAM in some schools and test some new assessment approaches. In case the results indicate that students learn better.

Furthermore, the teacher responded,

> *"The problem of large classes as a barrier to implementing STEAM. There are certain challenges in large classroom size such as failure to supervise and accommodate all students, but there is a need of modification measures" (P 17).*

> *"Teacher clarified, activities under STEAM require small groups in which the teacher can coach the groups. This would not be possible with 50-70 students" (P 20).*

According to teachers,

> *"School administrators usually lack knowledge and appreciation of STEAM education. They hope to show that their administrations could shift once the benefits are realized" (*P 9).

Without administration supporting STEAM, individual teachers would not be able to implement it regardless of the amount of training they have, but another teacher then said,

> *"There are actually some administrators who are willing to be innovative but are wary because they fear results*" (P23).

**DISCUSSION**

The results of teachers on STEAM education are in line with the past studies in developing nations. The understanding of STEAM as an integrated pedagogical orientation of many Public elementary teachers in Sukkur was comparable to studies by Wahono and Chang (2019) in Indonesia and Rinke et al. (2016) in the United States, where teachers conflated multidisciplinary teaching with actual integration.

Furthermore, Teachers were less aware regarding STEAM education, and some were very surprisingly well-informed having intuitive knowledge without any formal training in STEAM. This implies that the teachers have varying points of departure in their professional growth, which are relevant in the development of differentiated education that serves the teachers at their current levels in accordance with the aspect of coherence of (Desimone, 2009).

The fact that teachers showed a high interest in learning about STEAM after realizing that it could positively benefit them. This transparency implies that professional growth may be rooted in the inherent interest of the teachers and conforms to the frameworks of Desimone (2009) that states when teachers are professionally developed, their knowledge and skills grow, and that in turn alters the way teachers teach in the classroom.

The shallow knowledge of technology and engineering on the part of teachers. This difficulty is explained by the TPACK framework Mishra and Koehler (2006) which explains that effective STEAM instruction should be based on the integrated knowledge in the content, pedagogy and technology. This underscores the content focus feature of Desimone (2009) whereby the aspects of professional development should focus on all three areas as opposed to teaching them individually.

The focus of practical training by teachers instead of theoretical lectures is in line with successful research on professional development. According to Darling-Hammond, Hyler, and Gardner (2017), "the active learning opportunities were determined as the important features." Ring and colleagues (2017) showed that teachers who went through some learning in STEAM acquired more knowledge compared to those who were lectured. This is a direct indication of the principle of active learning which is put forward by Desimone (2009) in which teachers do not just listen, but they become actively involved in the process through the analysis they undertake. The requests of teachers to participate in demonstration lessons, observe and practice with feedback are indicative of advanced knowledge, this is consistent with Park (2016) in Korea. The focus on continuous mentoring and learning communities by teachers is consistent with recent studies.

The barriers that had been identified by teachers include resource constraints, curriculum pressures, large classes, and absence of administrative support, which are similar to those reported suggested by Murphy et al. (2019) and Ejiwale (2013). Nevertheless, the attitude of teachers to problem-solving and solutions they suggest makes these findings different. The realistic and hopeful attitude of teachers manifests professional maturity. Instead of merely complaining, a lot of solutions were Creatively given. such as using local resources, sharing resources, and starting small communities. This indicates that teacher professional development must enable them to be creative in operating on limited grounds, and this is what Desimone (2009) notes that the purpose of professional development should be eventual practice in classroom instructions despite the contextual obstacles. Examination pressure challenge is mirrored by greater systemic problems (Nayyar & Salim, 2012). Nevertheless, some teachers acknowledged that STEAM could even enhance the performance of examinations as it facilitates a deeper insight, which will be useful in overcoming resistance. The acknowledgment of the teachers that administrative support usually comes after the demonstrated success proves to be a strategically thinking step.

The observation that the teachers are unprepared and believe that they can learn can be interpreted as a significant psychological aspect. Although the lack of confidence may lead to non-implementation (El-Deghaidy and Mansour, 2015), the confidence of the Sukkur teachers in their learning potential may indicate that professional development that aims at the construction of self-efficacy and knowledge may be effective.

These results play significant roles in the positive change of professional development at Sukkur following the framework of Desimone (2009). Programs must also be content oriented by focusing on science, technology, engineering, arts, and mathematics integration.

These results indicate that Sukkur elementary teachers are quite sincere who have underlying knowledge, clear sense of needs, problem-solving skills, and desire to grow. Understanding the proper design of professional development in accordance with the main characteristics of Desimone (2009) regarding consideration of contexts, developing on the strengths, and sustaining support, STEAM education implementation seems to be possible despite the lack of resources.

These findings have several important implications for designing professional development in Sukkur. First, professional development should be differentiated based on teachers' varying starting points rather than assuming a one-size-fits-all approach. Second, programs should emphasize hands-on experiential learning where teachers engage in STEAM activities themselves before teaching them to students. Third, professional development should focus on low-cost, locally available materials rather than creating dependency on expensive resources. Fourth, programs should include ongoing support mechanisms such as mentorship and collaborative learning communities rather than stopping after initial training. Fifth, professional development should help teachers navigate systemic constraints rather than ignoring them. Sixth, teachers should be involved as partners in designing professional development that fits their contexts and needs.

These findings demonstrate that while Public elementary teachers in Sukkur face challenges, they also possess foundational understanding, clear awareness of their needs, problem-solving abilities, and commitment to professional growth. With appropriately designed professional development that respects their contexts, builds on their strengths, and provides sustained support, STEAM education implementation appears feasible despite resource constraints.

## CONCLUSION

This study provides crucial insights into STEAM education implementation in underserved Pakistan contexts, specifically addressing the significant gap in research on public elementary teachers'

perspectives in Sukkur, Sindh. By examining teachers' understanding, professional development needs, and implementation challenges in Sukkur, this research moves beyond assumptions to provide grounded evidence for developing contextually appropriate interventions.

The findings reveal that elementary teachers in Sukkur possess varied STEAM understanding, from limited awareness to surprisingly sophisticated intuitive grasp of integrated teaching. While they face genuine challenges, resource constraints, curriculum pressures, large classes, and limited administrative support they demonstrate remarkable problem-solving abilities, professional maturity, and commitment to student learning. Rather than passive recipients awaiting external solutions, these teachers show creativity in proposing contextually adapted approaches using local materials and collaborative support systems.

The key contribution of this study lies in challenging deficit-based narratives about teachers in poor-resource contexts. The research demonstrates that barriers to STEAM implementation are primarily systematic rather than individual. Teachers possess foundational understanding, recognize their professional development needs, and show readiness for growth when provided appropriate support. This finding shifts the discourse from "what teachers lack" to "what systems must provide" for successful implementation.

The study offers new insights for contextualizing STEAM education in developing countries. Instead of importing Western models requiring expensive resources, the research suggests viable pathways through peer based collaborative learning, locally available materials, and phased implementation with ongoing mentorship. Teachers' creative suggestions for working within constraints provide practical frameworks that respect local realities while maintaining educational quality.

This research establishes that STEAM education implementation in Sukkur's elementary schools is feasible despite resource limitations, provided professional development respects teachers' contexts, builds on their strengths, provides sustained support, and treats them as partners in design and implementation. The study provides the foundational understanding necessary for moving forward with contextually grounded STEAM initiatives in Sukkur, Sindh, offering a model potentially applicable to similar underserved regions globally.

**RECOMMENDATION**

For effective professional development on STEAM education, the Sindh Government should invest more funding on STEAM related projects and provide Continuous professional development opportunities where teachers engage in inquiry-based learning and learn the strategies to design interdisciplinary lessons more effectively.

Teachers should provide ongoing support and mentoring for impactful Professional development. Learning communities for STEAM education should be established where teachers can share innovative ideas and techniques to improve STEAM Education. Furthermore, Proper feedback mechanism and evaluations should be conducted for successful professional development.

School leaders can play a pivotal role in promoting STEAM Education by allocating flexibility of time, managing and organizing resources. Moreover, Leaders can encourage, observe, and provide constructive feedback on STEAM activities.

Future researchers are encouraged to examine the appropriate assessment methods for STEAM learning and also incorporate the opinions of School leaders and Students as well to examine the Significance of STEAM education more thoroughly. Moreover, researchers should monitor practical STEAM activities to witness the STEAM oriented challenges faced by teachers.

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