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## “Beyond Play: Reimagining Early Childhood Classrooms through STEAM Integration”

\* Mohtashma Habib, PhD Scholar (Corresponding Author)

\*\* Dr. Shazia Naureen, Assistant Professor

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### Abstract



*This paper discusses the introduction of Science, Technology, Engineering, Arts, and Mathematics (STEAM) in Early Childhood Care and Education (ECCE) in Pakistan. The study was descriptive employed quantitative survey. Sample of 50 trained ECCE teachers in 15 elementary schools from both public and private sectors was used to collect the data. The questionnaire consists of (25 items on five-point Likert scale) created by the researcher was used to assess how teachers perceive the effectiveness of the STEAM curriculum integration and its implementation at early childhood level. Expert review was set to create content validity; pilot testing (n=10) was used to refine items, and reliability analysis provided Cronbach's 0.87. Data analysis was conducted with the help of SPSS version 31 to calculate descriptive statistics, t-tests (0.0 = 4.0) to test the level of agreement among the teachers. It was shown by the Findings of current study that the perceptions of educators were positive (Effectiveness:  $M=4.23$ ,  $SD=0.67$ ; Implementation:  $M=4.19$ ,  $SD=0.72$ ) but there are still obstacles in the areas of resources, training, and curriculum alignment. The implications are those of an urgent necessity of professional development as a long-term phenomenon, provision of resources, curriculum change, and policy support required to make STEAM integration effective at early childhood level. The paper provides empirical evidence in the context of a developing country and presents the recommendations to policymakers, school leaders and educators.*

**Keywords:** STEAM Education, Early Childhood Education, Teacher Perceptions, Curriculum Implementation, Professional Development

### Introduction

In early childhood, the learning experiences that an individual goes through influence cognitive, social, and emotional development (UNESCO, 2021). Innovative education and creative thinking and problem-solving skills, which science, technology, engineering, arts, and mathematics (STEAM) education promote via transdisciplinary and inquiry-based learning, are the educational priorities of the present day (Maeda, 2013; Filipe, Baptista, & Conceicao, 2024). Although STEAM programs have taken root around the world (Su, 2025; Amanova, 2025), institutional evidence needs to be provided regarding the readiness of teachers and the systemic provisions in developing contexts. The paper investigates perceptions and practices of trained ECE teachers in Islamabad in order to inform scalable strategies of STEAM integration. Chesloff (2013) observed that early childhood is a critical stage of learning logical and mathematical thinking since the brain is very susceptible to such education at the age of one to four. The early experiences in mathematics and science can therefore be considered as a predictor of future success in any academic life. which explains why STEAM should start in early educational years of child.

### Literature Review

Science, technology, engineering, arts and mathematics (STEAM) developed on the basis of STEM and incorporates arts and humanistic aspect to make STEM more humanistic by stimulating the right hemisphere of brain which is related to creativity, innovation and artistic sense. which enhances science and technical learning (Maeda, 2013; Bequette & Bequette, 2012). The creativity and design thinking can be found in the history of the SMET to STEM and then to STEAM (Aguilera & Ortiz-Revilla, 2021). The emphasis on hand-on learning found in the STEAM may be applied in supplement to the Montessori, Reggio Emilia, and constructivist learning models (Edwards, Gandini, & Forman,

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\* Department of Educational Leadership and Management, International Islamic University Islamabad, Pakistan Email: [mohtashma.phdedu173@iiu.edu.pk](mailto:mohtashma.phdedu173@iiu.edu.pk)

\*\* Department of Educational Leadership and Management, International Islamic University Islamabad, Pakistan Email: [drshazia.naureen@iiu.edu.pk](mailto:drshazia.naureen@iiu.edu.pk)

2011; Montessori, 1964). The latest systematic reviews denote the expanding circles of empirical concern on STEAM in the early years that have beneficial impacts on involvement, affective facets, and the development of intricate abilities (Maulidiyah et al., 2023; Su, 2025; Amanova, 2025). Nevertheless, the barriers are also still singled out in the literature: the lack of professional development of the educators, lack of learning tools, irrelevance of the assessment, and institutional barriers (Erol & Erol, 2023; Martins et al., 2024; Camacho-Tamayo & Bernal-Ballen, 2023). This study on teacher training demonstrates that the specific professional development results in the rise of pedagogical confidence and the compliance with the implementation of STEAM curriculum (Martins et al., 2024; Erol, 2025).

Science, technology, engineering, arts and mathematics (STEAM) is a fairly new addition to the early childhood care and education (ECCE), which has a lengthy history of educational importance. Which is preoccupied with the concept of creativity, inquiry and holistic development. Initially, the acronym could be considered as SMET in the late 20<sup>th</sup> century. However, to enable interdisciplinary links between science, technology, engineering and mathematics, the acronym was changed to STEM. Nevertheless, it was later discovered by the scholars and teachers that arts and design thinking can be employed concurrently to develop creativity, innovativeness, and emotional intelligence that led to STEAM (Bequette & Bequette, 2012; Maeda, 2013). It was an establishment of an even greater pedagogical transformation to humanizing the learning of science and technology by encouraging problem-solving with innovation and aesthetic inquiry (Aguilera & Ortiz-Revilla, 2021).

The philosophy of science, technology, engineering, arts and mathematic (STEAM) was directly linked with the philosophy of early childhood pioneers, Maria Montessori, Jean Piaget, Lev Vygotsky and Loris Malaguzzi, who stressed the importance of learning based on a concrete exploration, inquiry and socialization. Montessori (1964) was a proponent of the prepared environment experiential learning. where children acquire new information by manipulating and discovering the surrounding. They also include the Reggio Emilia philosophy that has its roots in Malaguzzi, artistic expression, collaboration, and project-based inquiry that are closely related to the concepts of the STEAM (Edwards, Gandini, & Forman, 2011). It was also premised on the constructivist theories that consider children as creators of knowledge and learn best through experimentation, play and reflection (Piaget, 1970; Vygotsky, 1978).

Shifting to the present situation, Katz (2010) has noticed that the best early education settings can assist children to emerge as effective learners. Her case to argue was that young learners ought to wonder, interact and be at it as the experience would not only be a gain to them in learning STEAM but their future intellectual and cognitive learning as well. Katz (2010) had found that children are as curious as the scientist, through their play, watching and experimenting, children feel compelled to learn more about their world. She detected the intellectual interest and the inherent academic skills by indicating that reasoning, hypothesis, prediction and critical thinking should be instilled in the early childhood curriculum.

The same thought was voiced by Hoachlander and Yanofsky (2011), Bybee (2013) stated that the introduction of learning STEAM in the early childhood stage enhances the critical thinking, reasoning and problem-solving skills and develops the interest of discovery in the children. Children are intrinsically inquisitive and able students who are persistent and imaginative with regard to multisensory, integrative actions. Young learners create questions, find ways of solving them, searching and using knowledge in an intentional way and therefore, through inquiry-based projects in the STEAM field, learners come up with inquiries and curiosity (Concordia, 2017).

More recent empirical studies and systematic reviews support such theoretical underpinnings. It has also been established that the level of engagement, motivation, socio-emotional development and higher-order thinking improved in young children as a result of STEAM-based interventions (Maulidiyah et al., 2023; Su, 2025; Amanova, 2025). Nevertheless, even with these advantages, there are a specific number of difficulties, such as insufficiency of teacher training, lack of resources, inapplicability of assessment, and organizational restrictions (Erol & Erol, 2023; Martins et al., 2024; Camacho-Tamayo & Bernal-Ballen, 2023). It was established that there is an enormous influence of teachers' professional development programs on the quality of early childhood education which is gap between theory and classroom practice.

In general, history of science, technology, engineering, arts and mathematics (STEAM) model of early childhood care and education (ECCE) is one of the indications of paradigm shift to wholesome, enquiry based, and creative learning experiences. It was explored through many research studies that if the right pedagogies applied at early year classrooms and students taught by trained teachers the young children will be in a position to create a balanced base of cognitive, emotive and artistic intelligences that enable them to embrace the challenges of the future job market.

Moreover, the greatest contribution towards the study of early childhood care and education was made when Lilian G. Katz (2010) came up with the ideal approach towards the early childhood education by ensuring that the child is also a participant in the process of learning. Katz (2010) approved the practices whereby young learners would explore and engage in taking initiative and observed that the practices would not only advance the sciences, technology, engineering, arts and mathematics (STEAM) learning, but also create a significant difference in academic and cognitive performance. Such children according to Katz (2010) would be natural inquisitive people in the world and they would seek to learn it by observation, experimentation and play. In one of her conferences on science, technology, engineering, arts and mathematics (STEAM): in the Early Years, Katz said that a good early childhood curriculum should rouse the children to create the basis of the fundamental academic abilities, and it should also enable the children to develop intellectual curiosity, reasoning, hypothesizing, predicting, and thinking. According to this opinion, the role of the integration of the STEAM education in the early childhood classrooms could not be overestimated as it helps to promote the inquiry-based learning and cognitive progress.

Likewise, Hoachlander and Yanofsky (2011), Bybee (2013) will agree with this argument that the early exposure to science, technology, engineering, arts and mathematics (STEAM) will educate children who have a higher sense of critical thinking, reasoning, and discovery. Being curious and ambitious students, this is one of the key peculiarities of young learners and this is how ideally ideas of STEAM learning depicted. They may be good, powerful and active students, who may succeed as long as they have a chance to explore, to challenge and experiment. With the help of intensive and integrative experiences in STEAM, the children engage in guided inquiry, setting new questions, finding new answers, application of new knowledge, and creatively solving problems (Concordia, 2017).

#### **The Theoretical Foundation of this study**

This study has a theoretical basis that is grounded on constructivist learning theory given by Jean Piaget and Lev Vygotsky (Piaget, 1970; Vygotsky, 1978). According to this theory, learning is an active and dynamic process where people draw up new knowledge and understanding through their previous experiences, their cognitive structures and this is a result of their respective social and cultural conditions (Piaget, 1970; Vygotsky, 1978). Furthermore, Constructivism focuses more on problem-solving and reflection, whereby, a learner works on solving the problems in the real world, they will find out the results of their actions and develop more profound knowledge after reflecting on their past and current experiences (DeVries PC & Zan, 1995; Edwards, 2005; Texley & Ruud, 2017). Thus, learning must be interactive, experiential, and learner-centred, in which students take part in practical, real-life activities. Which promote inquiry and discovery. In this context, the teacher will be guide or facilitator and he will stimulate the thinking of the learners through questioning and scaffolding in order to enable them come up with their own interpretations and conclusions (Vygotsky, 1978; Edwards, 2005).

#### **Objectives of the Study**

1. The aim of the research is to examine the perception of teachers on the efficiency of STEAM integration in early childhood care and education.
2. To examine challenges in implementation of science, technology, engineering, arts and mathematic (STEAM) education approach in early childhood care and education.

#### **Research Questions**

1. What is the perception of trained ECCE teachers concerning the effectiveness of science technology, engineering, arts and mathematics (STEAM) method of education in early childhood classroom context?
2. What are the key obstacles in science, technology, engineering, arts and mathematic (STEAM) education approach implementations in ECCE?

### **Research Hypotheses**

1. H01: The perception of trained teacher with respect to the effectiveness of integrating science, technology, engineering, arts and mathematics (STEAM) education approach in early childhood care and education is not statistically different.
2. H02: There is no significant difference between the view of trained teachers about the application of science, technology, engineering, arts and mathematics (STEAM) education approach in early childhood care and education, which is significant.
3. H03: there is no significant statistical difference in the perception of trained teachers regarding challenges in implementation of science, technology, engineering, arts and mathematics (STEAM) education approach in the early childhood care and education.

### **Research Methodology**

The study based on descriptive research design based on quantitative survey taken to capture the perceptions of trained ECCE teachers and the practices they reported as relating to STEAM integration. With that design, it will be possible to evaluate existing attitudes and determine the obstacles in implementation of STEAM education approach at early childhood level (Creswell, 2014).

### **Population and Sampling**

The target population was consisting of all ECCE teachers in both public and private elementary schools in Islamabad who were listed as using or piloting STEAM activities. The availability of an accessible population of 60 trained ECCE teachers in 15 schools was found due to logistical constraints. The participants were selected by a simple random sampling method. who participated in the pilot test and further reduced to 50 subjects in the final sample to provide each of the eligible teachers with an equal opportunity to be selected (Gay, Mills, & Airasian, 2012)?

### **Instrumentation**

Researcher designed questionnaire (25 items and three subscales) including (a) Effectiveness of STEAM integration in ECCE (10 items), (b) Implementation of STEAM in ECCE (10 items), and (c) Challenges in integration of STEAM in ECCE (5 items) were used to collect data. Items considered on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Demographic questions (teaching experience, training history, school type) were also represented in the questionnaire.

### **Validity, Pilot Testing, and Reliability**

The content validity was determined by having 12 experts in the subject matter of STEAM and ECCE review the items and rated them on their relevance and clarity. items that had poor consensus were edited or deleted. Pilot test on 10 ECCE teachers (not the focal sample) was performed to check on clarity and timing; small wordings alterations enhanced the comprehension of the items. The reliability measured using Cronbach's alpha gave 0.87 to the entire instrument with subscale alpha of 0.85 (Effectiveness), 0.83 (Implementation), and 0.79 (Challenges), acceptable internal consistency was achieved (Nunnally & Bernstein, 1994).

### **Data Collection Procedure**

Ethical consent was taken from the stakeholders of study and approval was obtained. Informed consent sheets and information sheets were given to teachers on the purpose of the study. Assurance of confidentiality and voluntary participation. The questionnaires were conducted in two ways, one by paper during the staff meeting and another online through the Google Forms application where respondents who chose to do the questionnaire online. Data was collected in a period of four weeks. All the responses were anonymous and stored on an encrypted drive that can only be accessed by the research team.

### **Data Analysis Procedure**

The analysis of data was done using the recent version of SPSS (31). Initial screening checks were done on missing values, normality (skew/kurtosis) and outliers. Responses to the samples and items were represented using descriptive statistics (means, standard deviations, frequencies). Inferential analysis included one-sample t-tests of the sample mean against a previously set benchmark (0 = 4.0, strong agreement), with 0.05 (two-tailed). Cohen d (effect sizes) have been computed to derive practical significance. Open-ended items generated qualitative data which underwent a thematic analysis to supplement the results obtained quantitatively.

### **Descriptive statistics**

There were 50 trained teachers who were ECE (response rate: 83%).

**Table 1**  
*shows the key variables descriptive statistics.*

Variable	N	Mean	SD	Min	Max
Effectiveness of STEAM integration in ECE	50	4.23	0.67	2.8	5.0
Implementation of STEAM in ECE	50	4.19	0.72	2.5	5.0
Challenges in integration of STEAM in ECE	50	3.46	0.88	1.4	5.0

**Inferential Statistics:**

One-sample t-tests were used to determine whether the mean ratings of teachers did not significantly differ with the benchmark which was assumed to be 4.0 (0 = 4.0).

**Table 2.**  
*The inferential statistics is summarized in*

Variable	N	Mean	SD	SE	t	df	p (two-tailed)
Effectiveness of STEAM integration in ECE	50	4.23	0.67	0.095	2.42	49	0.008
Implementation of STEAM in ECE	50	4.19	0.72	0.102	1.86	49	0.031
Challenges in integration of STEAM in ECE	50	3.46	0.88	0.124	-4.35	49	0.00

Interpretation: In both Effectiveness (t = 2.43) and Implementation (t = 1.87), the t-values calculated are less than the critical value (t critical (49) = + 2.009) implying that the null hypothesis is not rejected in that the mean rating of teachers is not significantly different in terms of strong agreement (mu 0 = 4.0). The Challenges mean (M = 3.46) is less than the benchmark, which is perceived gaps in resource provision.

**Results**

The teachers gave a relatively high consensus rates on the effectiveness and appropriateness of STEAM integration in ECCE (M ≈ 4.2) which is a positive sign that they were highly positive perceptions towards transdisciplinary pedagogy. There was positive self-reported uptake (M 4.19) in implementation practices. The Challenges in integration of STEAM in ECCE (M = 3.46) pointed out the lack of resources, the lack of continuous professional development, and the curriculum constraints as the significant obstacles.

**Discussions**

According to the results of this research, perceptions of early childhood educators were positive regarding the integration of science, technology, engineering, arts and mathematics (STEAM)-based education in Early Childhood Care and Education (ECCE)-classrooms. Such attitudes can be well-understood by the findings of international research suggesting that teachers consider STEAM as an efficient model of promoting creativity, engagement, and critical thinking in young learners (Maulidiyah et al., 2023; Erol & Erol, 2023). The fact that the findings of this study were consistent with international trends may indicate that there is an increasing agreement that STEAM-based interventions could not only be developmentally appropriate but also pedagogically effective to the promotion of holistic child development.

Moreover, the research study is In line with the constructivist paradigm given by Piaget (1970) and Vygotsky (1978), the results confirmed that instructors view learning as dynamic, inquisitive, and practical. Teachers acknowledged that STEAM helps children to learn about the world around them and do it by observing, experimenting, and collaborating, which is reflected in the works by Katz (2010), who believed in the significance of experiential and child-driven learning in the early years. This favourable attitude indicates that educators theoretically perceive the transformative possibilities of STEAM in the development of cognitive and creative aspects of growth.

Nevertheless, regardless of this perception, the findings also present the ongoing issues that impede the consistent application of STEAM in the ECE setting. As in the case of the authors, Martins et al. (2024) and Camacho-Tamayo and Bernal-Ballen (2023), the teachers in this study also mentioned barriers to the resources available, insufficient training, and the mismatch of curriculum in their responses. These conclusions highlight the gap between the learning of the theoretical and the practical ability of teachers to provide the integrated STEAM experience in low-resource settings. Although the interest towards STEAM is evident, the resources needed to implement it properly in terms of infrastructure, time management, and administrative tools are not enough.

As per Amanova (2025) and Su (2025), the lower means scores that were obtained in the area of challenges also highlight that the systemic and institutional support is necessary. Teachers need

continuous professional development of the type, which cannot be reduced to workshops; continuous mentoring, joint lesson planning and reflective practice are the aspects of professional growth in question. These programs would help teachers to transform their theoretical understanding to pedagogically viable inquiry-based classroom activities. Additionally, it is important to invest in contextually relevant material and align curriculum in order to make STEAM programs within early learning systems sustainable.

This paper also supports the hypothesis that teacher professional development is a major aspect in science, technology, engineering, arts and mathematics (STEAM) education in the success of Early Childhood Care and Education (ECCE). Teachers who feel empowered and equipped would find it easier to incorporate STEAM in their daily learning process as noted by Erol and Erol (2023). These results therefore demand institutional and policy leadership to provide enabling environments to foster experimentation, collaboration and innovation among early childhood teachers.

In a more general sense, these findings are a part of the developing discussion on the topic of STEAM education in the early years, in which learning is not seen as the active process of acquisition of skills but rather as the process of discovery and expression. The congruence between the attitudes of teachers and constructivist theories of learning implies that ECCE professionals have a good chance to apply STEAM pedagogies in case they are provided with the relevant support. Teachers can use STEAM as the third way between play-based learning and cognitive development, developing a scientific interest and an artistic imagination in small children.

Concisely, the discussion indicates that even though teachers have a high level of conceptual approval of STEAM, system level obstacles still hinder the full implementation of the idea in ECCE classrooms. To continue this momentum and scale, it will be important to address these constraints by focusing on professional development, resource material provision, and integrating the curriculum. The implications of these insights are quite important to the policy makers, teacher educators and curriculum developers who want to build in science, technology, engineering, arts and mathematics (STEAM) education in the Early Childhood Care Education (ECCE) systems to encourage creativity, inquiry and lifelong learning.

#### **Practical Implications**

1. Science, technology, engineering, arts and mathematics (STEAM) education competencies need to be incorporated into the national ECCE curricula, and special funding allocated to early years STEAM resources.
2. The program of teacher education should incorporate STEAM pedagogies and practicum elements.
3. Schools' ought to foster collaboration with local institutions of higher learning and industry to obtain maker-space and mentorship.
4. Performance based evidence of creativity, collaboration and inquiry should be encouraged by assessment systems.

#### **Conclusions**

The paper explored attitudes, perception, and challenges of the early childhood educators towards the integration of science, technology, engineering, arts and mathematics (STEAM) education approach in Early Childhood Care and Education. Its findings revealed that the teachers are generally positive in their attitudes and possess excellent conceptual knowledge on the significance of STEAM in promoting creativity, engagement, critical thinking, and the holistic development of the child. Such perceptions aligned with the literature across the world, who has stressed the fact that STEAM based methods provide meaningful inquiry-based learning experiences that support cognitive and emotional growth (Katz, 2010; Maulidiyah et al., 2023; Erol & Erol, 2023).

Despite these positive impressions, the research determined that there are several systemic and institutional problems of constraint in successful implementation of STEAM curriculum at ECCE level. They include the lack of professional development, the lack of instructional resources, the incompatibility of a curriculum, and the lack of administrative support, which are associated with the findings of Martins et al. (2024), Camacho-Tamayo & Bernal-Ballen (2023), & Amanova (2025). Teachers are normally de-motivated and not ready to transform the ideas of STEAM into sustainable classroom lessons. The difference gives a distinct idea of how desperately the comprehensive support system is required, a system that would assist fill the gap between teacher enthusiasm and action and a system who play an important role in teachers motivation and awareness toward STEAM.

In simple words, the research results has shown a high level of attitudinal base of STEAM adoption, but weak operational base and the operational preparation is also weak. In addition to the teacher initiative of sustainable integration of STEAM in ECCE, institutional commitment, the continuous training process, and facilitating learning environments was found obligatory. These gaps will be identified to ensure that STEAM will not act as an isolated innovation; it will become the internalized system of pedagogy. which will encourage innovation, collaboration, and problem-solving since the first days of learning.

To sum up, STEAM education approach in ECCE/ECE has the potential to transform the early learning setting in Pakistan since it will facilitate the cultivation of curiosity, creativity, and critical thinking. However, it involves a long-term commitment of the policy, funds and educating the teachers to ensure its success. Thus, the idea of improving ECCE according to STEAM is in accordance with the Vision 2030 of knowledge-based development in Pakistan.

### **Recommendations**

- i. Provide early childhood courses based on low-cost, -appropriate science, technology, engineering, arts and mathematics (STEAM) kit.
- ii. On the foundations of the STEAM-based instruction and the practical design thinking and inquiry-based learning, which will be age-specific, the professional learning plans should be developed (Bybee, 2013; Su, 2025).
- iii. Create peer learning communities or so-called STEAM Learning Circles, during which the teachers will have the possibility to discuss lesson plans and share classroom experiences and jointly create the activities that will be applicable in the ECCE context.
- iv. Implement STEAM units to pre-service teachers in preparation of future teachers with the primary foundations of interdisciplinary education.
- v. Integrate national and institutional Early Childhood Care and Education (ECCE) curriculum with the science, technology, engineering, arts and mathematics (STEAM) education.
- vi. Encourage transdisciplinary learning initiatives in which courses are co-located on significant themes in life like: Nature and Sustainability or Community and Innovation.
- vii. Introduce arts and cultural expression as the core of teaching process of STEAM, in such a way that children can learn to apply their imagination, emotions, and taste of the beauty (Bequette & Bequette, 2012; Maeda, 2013).
- viii. Present early age learning materials, manipulatives, and technological accessible resources which support in ECCE classroom exploration and experimenting (Amanova, 2025).
- ix. Promote elementary schools to establish STEAM maker spaces or discovery laboratories in which children may use directed inquiry by using constructive materials, experimentation, and creativity.
- x. Collaborate with universities and other science centres and art institutions in the area that will offer practical learning and resource trade.
- xi. The policy-makers need to concentrate on the policy of STEAM introduction to the early childhood care and education, devote appropriate funds to the training of the teachers, development of the materials and for conduction of pilot programs.
- xii. Create monitoring and evaluation teams in order to determine the efficiency of the inclusion of STEAM programs in ECE and determine the most effective grading practices.
- xiii. Train administrative leaders, who should be capable of learning the academic utility of STEAM and offer institutional support on a long-term basis.

### **Suggestions for Future Research**

- i. Conduction of longitudinal studies to determine the long-term effects of early exposure to STEAM on the academic achievements of children, creativity, and problem-solving abilities.
- ii. Conduct comparative research in a wide variety of cultural and socioeconomic contexts in order to develop contextually relevant science, technology, engineering, art and mathematics (STEAM) education in Early Childhood Education (ECCE).
- iii. Use Mixed-methods and action research methods to document the lived experience of teachers and create grounded practice-based frameworks of the implementation of STEAM education approach.

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