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Impact of STEAM Education on Creativity Development in Science Classrooms: Perception of High School Students

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Abstract

This survey-based study explored the perceptions and practices of 120-150 high school students in Multan, Pakistan, regarding STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. Using a simple random sampling technique, data were collected from students across various academic disciplines, including Social science and Humanities, Science-Technology & Engineering, Computer sciences, Management sciences, Medical and Health sciences. A 17-items questionnaire based on a 5-point Likert scale measured three categories: Awareness (2 dimensions), Perception (8 dimensions), and Implementation (3 dimensions). The findings reveal that while awareness and positive perceptions of STEAM education are relatively high among high school students, actual implementation remains limited due to a lack of resources and hands-on activities. The study indicates that 88% (n=133) of students believe STEAM-based education can improve technological and scientific development in Pakistan. Despite this, only 18% (n=27) reported frequent hands-on STEAM activities, and just 28.7% (n=43) acknowledged sufficient resources in their institutions. Therefore, greater institutional support and curriculum integration are necessary to fully realize the benefits of STEAM education in Pakistan. The study highlights the need for improved planning and application of STEAM approaches to fully realize their potential in educational settings.

Keywords: STEAM, STEM, Creativity, Critical thinking, problem solving

Introduction

The ability to think creatively is of vital importance for success in every field, particularly in the modern world. Creative thinking enhances individuals' ability to come up with innovative solutions and think outside the box. It helps in problem-solving and expressing themselves in unique ways. Educators and researchers pay close attention to creativity for holistic development of individuals. Also PISA 2021 was focused on the issue of creative thinking in schools. It is the need of the hour to foster and develop creative thinking skills in schools so that students are well prepared for the challenges of academic and professional lives.

Although many researchers or educators have recognized the importance of creativity in science education, formal education in schools still lacks systematic training courses to nurture it (Tran *et al*, 2021). Although there are several approaches to creativity, most of the prior research highlights four core elements: action, production, disequilibrium, and sensitivity to a problem. In summary, creativity can be seen as a human ability to perceive unbalanced situations and



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engage in productive efforts, ultimately leading to the creation of something new—whether physical or emotional—and solving problems practically.

Most educators suggest that creativity can be achieved through learning. Therefore, it is the belief of many renowned educators and scholars of the world that creativity is one of the primary goals of education and key factor for the future success. Creativity is particularly important in science education, as it enables students to tackle problems from varied angles, think with innovation, and create solutions to real-world challenges (Henriksen, Mishra & Fisser, 2016).

However, the absence of standardized creativity-training programs in formal science education and the limited training of scientific creativity among high school teachers present significant barriers (Tran *et al*, 2021).

Historically, science education has prioritized memorization and standardized assessments, often neglecting creativity and hands-on problem-solving (Kim, 2016). However, as global challenges grow, there is increasing recognition among educators and policymakers on the importance of preparing students for careers that demand creativity, interdisciplinary thinking, and adaptability (Quigley, Herro & Jamil, 2017). STEAM strategies strictly address these needs by integrating artistic practices into scientific processes, encouraging students to approach scientific problems through creative exploration and design. The integration of STEAM into science education classrooms marks a dynamic shift from traditional teaching methods toward holistic, multidisciplinary learning approaches. Research highlights that STEAM fosters creativity, critical thinking, and innovation by bridging the gap between the sciences and the arts, making science education more engaging and relevant (Henriksen & Mishra, 2015).

Additionally, the integration of STEAM strategies aligns with Pakistan's National Education Policy, which focuses on the importance of fostering innovation, creativity, and critical thinking to make students able for the challenges of a globalized world.

By addressing these gaps and focusing on the Pakistan's context, this action research aims to investigate the implementation of STEAM strategies in science classrooms to foster creativity among students. By integrating artistic approaches with scientific inquiry, this research will assess the impact on student engagement, creativity, problem-solving skills, and conceptual understanding. The findings will contribute to the development of more effective teaching practices and provide recommendations for the successful implementation of STEAM approaches in Pakistan's schools.

Background of the Study

In recent years, **STEAM (Science, Technology, Engineering, Arts, and Mathematics)** education has emerged as a transformative approach for fostering creativity, critical thinking, and problem-solving skills among students. This interdisciplinary approach integrates the arts with traditional STEM (science, technology, engineering, mathematics) subjects to provide a more holistic learning experience. As the global economy has started recognizing innovation, adaptability, and creativity, there is a transformative move that education must evolve to equip students with the skills required for the future development (Beers, 2021). The need for such an approach is particularly essential in science subjects, where rote memorization and standardized testing have been the dominant methods of assessment from centuries, sidelining creativity and limiting students'



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ability to think critically (Henriksen, Mishra & Fisser, 2016).

Globally, many developed countries have started to incorporate STEAM strategies into their educational systems, appreciating their potential to foster interdisciplinary learning and enhance creative problem-solving. In countries such as the United States, South Korea, and the United Kingdom, STEAM initiatives have documented positive outcomes, including increased student engagement, enhanced critical thinking and collaboration across disciplines (Yakman & Lee, 2012). These outcomes have not been equally mirrored in developing countries, particularly in regions like South Asia. In developing countries, traditional teacher-centered educational approaches continue to dominate, and creativity is often undervalued in the classroom.

In Pakistan, the education system also remains heavily reliant on rote learning, with little emphasis on fostering creativity and critical thinking. The curriculum, particularly in science education, is primarily focused on memorizing facts and concepts, leaving little space for students to interact with study material in a creative way. The Single National Curriculum (SNC), introduced in recent years, aims to standardize educational content across the country. While it makes efforts towards conceptual learning, it still lacks in promoting creativity and critical thinking, particularly in science classrooms. Studies have shown that the rigid focus on exams and memorization minimizes opportunities for students to grow and develop in creative way. This is compounded by the scarcity of resources, especially in rural public schools, where outdated teaching strategies and limited access to modern technology hinder the adoption of more innovative approaches like STEAM.

Despite the unavoidable challenges, there has been some exploration of STEAM in the Pakistani context. However, research on its practical implementation remains inadequate. Some studies have elaborated the potential of integrating technology and science education in private or urbanized schools, where resources are more readily available. Still, such studies do not adequately address how STEAM strategies can be adapted to the diverse socio-economic backgrounds of Pakistan, particularly in rural and underfunded schools. This creates a significant gap in knowledge, as the applicability and effectiveness of STEAM strategies in resource-constrained environments have not been extensively explored.

Furthermore, there is a lack of teacher training and professional development programs in Pakistan that focus on creativity and interdisciplinary learning. Many teachers are not aware of the implementation of STEAM strategies and may struggle to integrate arts into their science lessons effectively. The professional development systems in Pakistan are primarily inclined toward traditional teaching methods, which further limits the potential for fostering creativity in science classrooms. Therefore, there is a dire need to explore how teachers can be equipped with the appropriate tools, resources, and training to effectively integrate STEAM strategies into their teaching practices.

Cultural and societal barriers also add more hurdles in the development of creativity in the education system. In Pakistan, there is a cultural preference for traditional career paths, such as medicine, engineering, and business, which are seen as more fruit giving and financially rewarding occupations. As a result, both students and parents run after these professions, neglecting the need of creativity or innovative thinking. This builds a societal mindset that undervalues the



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importance of creative subjects and interdisciplinary learning.

In conclusion, while there is an extensive growth in STEAM education globally, its application in Pakistan remains halted. There is an utmost need for research that explores how STEAM strategies can be tailored to address the challenges of Pakistan's education system. This study aims to fill these gaps by analyzing the practical application of STEAM in Pakistani science classrooms, emphasizing on fostering creativity and critical thinking in a resource-deficit and exam-centric environment. The findings of the research will offer actionable insights for educators to shape the policy development and inclusion of creative approaches in the national curriculum, making education more relevant with 21st century skills.

History of the Topic: STEAM Strategies for Fostering Creativity in Science Education

The concept of integrating the **arts** into **STEM (Science, Technology, Engineering, and Mathematics)** education, later rebranded as **STEAM**, emerged in the early 2000s as educators and researchers began recognizing the limitations of traditional STEM education. While STEM education emphasizes technical proficiency in the sciences and mathematics, it often overlooks the development of creativity, which is essential for innovation. The introduction of the arts into this framework aimed to address this gap by encouraging students to approach problem-solving from a more creative, interdisciplinary perspective.

The roots of the STEAM movement can be traced back to the work of **Georgette Yakman**, who in 2006, first coined the term STEAM, emphasizing the integration of art into the STEM disciplines. Yakman and her colleagues argued that traditional STEM education often fails to encourage the creativity and critical thinking needed for students to innovate and tackle complex problems (Yakman & Lee, 2012). By including the arts, STEAM aims to enrich the learning experience, allowing students to explore the interconnectedness of scientific and artistic thinking, and to develop both analytical and creative skills.

By the mid-2010s, STEAM initiatives began to take root in countries like the United States, where school districts, educational foundations, and nonprofits organizations began developing programs that integrated arts into STEM teaching. These programs sought to provide students with opportunities to engage in project-based learning that required collaboration across disciplines and the use of multiple forms of expression (Beers, 2021). Many of these initiatives focused on fostering creativity through hands-on, real-world projects in which students were encouraged to solve problems creatively, using knowledge from science, engineering, technology, mathematics, and the arts.

In Pakistan, however, the formal adoption of STEAM strategies has been slower. Despite the growing importance of creativity and critical thinking in the global educational discourse, Pakistan's science education remains predominantly focused on rote learning and standardized assessments. However, some studies have begun exploring the integration of STEAM in the context of Pakistani classrooms, particularly in urban, private, and more resource-rich schools. These studies suggest that while there is an interest in incorporating more creative approaches to science education, challenges such as limited teacher training, lack of resources, and an entrenched exam-centric educational culture continue to hinder the widespread adoption of STEAM strategies.



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In the last decade, Pakistan has made some strides toward educational reform with the introduction of the Single National Curriculum (SNC) in 2020, which aims to standardize the educational experience across the country. While the SNC aims to promote conceptual learning over rote memorization, its emphasis on creativity and interdisciplinary learning remains limited. Research on STEAM's integration within this framework is still in its early stages, with few studies focusing on how STEAM can be adapted to the unique needs of the Pakistani education system.

The importance of creativity in science education is increasingly recognized in Pakistan, as it is seen as critical for developing problem-solving skills among students and preparing them for the challenges of the future. However, the shift towards STEAM education in Pakistan requires significant adaptation to local contexts, particularly in rural areas where access to resources is limited. The global trend towards creativity in education presents an opportunity for Pakistan to reform its educational system by integrating creative thinking into science classrooms, yet more research is needed to explore how STEAM can be effectively implemented in the diverse socio-economic and cultural contexts of Pakistan.

This study, therefore, is timely and essential as it seeks to explore how STEAM strategies can be adapted to the Pakistani education system to foster creativity in science education. Through a focus on teacher training, classroom practices, and curriculum design, this research will contribute to the development of a framework for integrating STEAM into Pakistani science education, ensuring that students are better equipped for the demands of a rapidly changing world.

Problem Statement

The Pakistani education system's inflexible, exam-focused curriculum limits creativity and interdisciplinary learning in science classrooms in high schools. The lack of STEAM integration further hinders students' ability to develop problem-solving and innovative thinking skills. Resource constraints, teacher preparedness, and cultural barriers make implementing STEAM strategies challenging. This study explores practical, resource-efficient STEAM approaches to enhance creativity in science education and address these contextual challenges.

Research Objectives

1. To investigate the impact of STEAM strategies on high school students' creativity among science students in Pakistani schools
2. To identify potential barriers in implementing STEAM strategies in Pakistan
3. To assess the feasibility and sustainability of STEAM strategies in underfunded and public schools in Pakistan

Research Questions

1. How does the integration of arts into science lessons affect students' engagement and creativity?
2. How do students perceive the impact of STEAM strategies on their learning and creativity?
3. What challenges do educators face while applying STEAM approaches in science education?

Significance of Study



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This study holds great significance in terms of current context of Pakistan's education system, which struggles to prepare students for a rapidly evolving modernized world. Traditionally, education in Pakistan has focused on rote memorization and exam-oriented learning, which hinders the ability to think critically and creatively. As the global workforce demands skills like problem-solving, innovation, and creativity, fostering these abilities early on in students has become essential. This study aims to investigate and explore the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) strategies in science education to foster creativity among students. By blending arts with the traditional STEM subjects, STEAM offers a more comprehensive learning approach that inspires students to think outside the box and approach problems from multiple angles.

Through this research, teachers will be equipped with practical, resource-conscious strategies for incorporating creativity into their daily science lessons. The study will also explore how these strategies can address common challenges in Pakistani schools, such as limited resources and outdated teaching pedagogy. As a result, the study has the potential to revolutionize science education in Pakistan by making it more engaging, innovative, and aligned with the essential 21st century skills. Moreover, the study will guide policymakers in modernizing curricula and educational policies, contributing to an education system that goes beyond knowledge transmission to empower students as creative thinkers capable of addressing real-world challenges.

Literature Review

Creativity is a multifaceted concept that has been defined and studied across various disciplines, including psychology, education, and cognitive science. In the educational context, creativity involves generating innovative ways to approach problems, fostering original thinking, and encouraging students to make meaningful connections between ideas (Beghetto & van Geffen, 2024). This definition highlights two core components of creativity: originality and effectiveness, both of which are essential for fostering innovation in science education. In science education, creativity is not limited to artistic expression but extends to scientific inquiry, problem-solving, and experimentation.

Frameworks for Creativity

Several theoretical frameworks provide a foundation for understanding and assessing creativity. Among the most influential is Guilford's (1950) Structure of Intellect model, which introduced the concept of divergent thinking as a key component of creativity. Divergent thinking involves generating multiple solutions to a problem, emphasizing fluency, flexibility, originality, and elaboration. These dimensions have since become central to creativity research and assessment.

Amabile's Componential Model of Creativity (1983) offers another perspective, identifying three primary components of creativity: domain-relevant skills, creativity-relevant processes, and intrinsic motivation. According to this model, creativity emerges when individuals possess the necessary skills and knowledge in a given domain, employ creative thinking strategies, and are intrinsically motivated to engage in the creative process. This framework is particularly relevant in education, where teachers can influence motivation and



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provide opportunities for students to develop domain-specific skills.

Vygotsky & Cole, (1978) sociocultural theory also contributes to the understanding of creativity by emphasizing the role of social and cultural contexts. Vygotsky argued that creativity is shaped by interaction with others, cultural tools, and shared experiences. This perspective aligns with collaborative and inquiry-based learning approaches in science education, where students engage with peers and educators to construct knowledge and generate innovative ideas.

Importance of Creativity in Science Education

The integration of creativity into science education is essential for fostering critical thinking, problem-solving, and innovation. According to Sawyer (2019), creativity is a vital skill for addressing complex global challenges, such as climate change, technological advancements, and public health crises. By encouraging students to think creatively, educators can prepare them to navigate these challenges with confidence and competence.

Research highlights several benefits of promoting creativity in science education. Creativity plays a critical role in developing students' scientific inquiry skills. According to Maker, Peasen & Zimmerman (2023) inquiry-based learning activities that prioritize creativity enable students to formulate research questions, design experiments, and interpret data in innovative ways. This approach not only enhances their scientific knowledge but also cultivates essential skills for lifelong learning.

Recent Advances in Creativity Research

Recent studies have expanded the understanding of creativity in educational contexts, emphasizing its dynamic and context-dependent nature. For example, (Beghetto & van Geffen, 2024) introduced the concept of "mini-c" creativity, which refers to the personal and transformative processes of making sense of new ideas and experiences. This perspective highlights the importance of recognizing and nurturing creativity in everyday classroom activities.

Technological advancements have also influenced the study and practice of creativity in education. According to Lu & Chen (2025) digital tools such as virtual labs, simulation software, and collaborative platforms provide new opportunities for fostering creativity. These technologies enable students to experiment with scientific concepts in innovative ways, enhancing their ability to generate and test hypotheses.

Another emerging trend is the use of neuro-educational research to explore the cognitive processes underlying creativity. Studies by Beaty *et al.* (2016) have identified neural networks associated with divergent thinking and creative problem-solving, providing insights into how educators can design activities that stimulate these processes. For example, activities that involve open-ended problem-solving, brainstorming, and interdisciplinary connections are shown to activate the brain's default mode network, which is associated with creativity.

Emerging STEAM Approach: Evolution from STEM to STEAM

The transition from STEM (Science, Technology, Engineering, and Mathematics) to STEAM (Science, Technology, Engineering, Arts, and Mathematics) represents a paradigm shift in education that recognizes the importance of creativity and holistic thinking. While STEM focuses on technical and analytical skills, the inclusion of the arts emphasizes innovation, design thinking, and emotional



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engagement, which are critical for addressing complex, real-world challenges.

Lu & Chen (2025) described the evolution from STEM to STEAM as a response to the limitations of a purely technical focus in education. By incorporating the arts, educators aim to prepare students not only for technological advancements but also for the social and ethical dimensions of innovation. The STEAM approach bridges the gap between technical expertise and creative expression, fostering well-rounded individuals capable of tackling interdisciplinary challenges.

Benefits of STEAM Education

Enhancing Innovation and Creativity

The inclusion of the arts in STEM education enhances students' ability to think creatively and innovate. Arts in STEAM encourages students to explore multiple perspectives, experiment with new ideas, and develop original solutions. For example, integrating design principles into engineering projects enables students to approach problems with a focus on aesthetics, usability, and user experience.

Promoting Holistic Thinking

STEAM education fosters holistic thinking by encouraging students to consider the interconnectedness of disciplines. The arts, in particular, help students understand the social, cultural, and emotional contexts of scientific and technological advancements. This approach aligns with Vygotsky & Cole, (1978) sociocultural theory, which emphasizes the role of cultural tools and shared experiences in learning. Overall, Arts also play a crucial role in developing empathy and communication skills. These competencies are essential for collaboration and for understanding the human impact of scientific and technological innovations.

Engaging Diverse Learners

STEAM education is particularly effective in engaging diverse learners by catering to various learning styles and interests. Students who may not initially resonate with STEM subjects often find the inclusion of the arts more relatable and inspiring.

Interdisciplinary Learning

STEAM education emphasizes interdisciplinary learning, where students integrate knowledge and skills from multiple disciplines to address complex problems. For example, a project on sustainable urban planning might combine principles of environmental science, engineering, and visual design. This approach encourages students to make connections across disciplines, fostering a deeper understanding of the material and its real-world applications.



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Transdisciplinary Learning

Trans-disciplinary learning takes interdisciplinary connections a step further by focusing on real-world problems that transcend disciplinary boundaries. In STEAM education, this often involves engaging with community issues, global challenges, or entrepreneurial ventures. For instance, students might design a campaign to raise awareness about climate change, incorporating scientific research, digital media, and storytelling.

Trans-disciplinary approaches in STEAM education help students develop transferable skills, such as critical thinking, communication, and adaptability. These skills are essential for navigating the complexities of the modern world.

Data Collection

Research Design

The study adopts a quantitative approach to examine students' perceptions of STEAM education and its implementation from matric to university level. Using a structured questionnaire survey, numerical data were collected to identify trends and explore how STEAM strategies influence creativity in science education. The design allowed for objective analysis of current perceptions and practices. Informed consent was obtained, and participation was voluntary, with assurances of confidentiality and exclusive use of data for research purposes.

Research Participants

The survey was conducted with a total of 150 students from Multan, Pakistan, representing a diverse sample in terms of educational qualifications, academic streams, and institutional backgrounds. Participants included students from secondary, higher secondary, undergraduate, postgraduate, and doctoral levels, spanning various disciplines such as Science, Economics, Arts, Engineering, Architecture, Computer Science, and Business Management. Table 1 provides a detailed breakdown of the participants by gender, qualification level, and academic stream.

Sampling technique

The simple random sampling method was adopted for the study. The sampling method comes under the probability sampling technique where every individual from the population have equal chance to participate and record their perspectives.

Data Collection Instrument

The primary instrument for data collection was a survey questionnaire designed to measure students' perceptions and implementation of STEAM strategies in their science education. The survey was carefully structured to ensure clarity, relevance, and alignment with the research objectives. It consisted of 17 questions, including closed-ended items.

The survey was divided into the following sections:

1. **Demographic Information:** Questions to gather background details such as age, grade level, and previous exposure to STEAM activities.
2. **Awareness of STEAM strategies:** A series of questions to assess the awareness of students about STEAM strategies.
3. **Perception of STEAM Strategies:** A series of Likert-scale questions to



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assess students' engagement, and opinions about STEAM-based learning methods.

4. **Creativity in Science Education:** Items designed to evaluate how students perceive the impact of STEAM strategies on their creative thinking, problem-solving abilities, and engagement in science education.
5. **Implementation of STEAM strategies:** Close-ended questions including students to share their experiences, hands on activities in their educational institutions and recommendations for improving STEAM-based approaches in their classrooms.

Ethical Considerations

The study maintained high ethical standards throughout data collection. Participants were informed about the study's purpose, methods, and benefits. Informed consent was obtained, participation was voluntary, and students could withdraw at any time without consequences. All data was kept confidential and securely accessible only to the researcher and authorized personnel.

Data Analysis and Findings

The descriptive, frequency data analysis and percentage was used to analyze the data.

Demographic details

Three key demographic variables were considered in this study: gender, educational qualification, and age. Most participants were at the graduation level, followed by post-graduation, intermediate, and doctorate levels.

Regarding academic streams, 48% (n = 73) of the participants were from Science, followed by Technology (12%, n = 19), Engineering (10%, n = 15), Arts (6.6%, n = 10), and others. This higher representation of science students may be attributed to their stronger connection and familiarity with the concept of STEAM education.

Table 1 Demographic Details of Respondants

Demographic details of survey participants Variable	Frequency (n)	Percentage (%)
Gender		
Male	68	45.3%
Female	81	54%
Qualification		
Ph.D.	12	8%
Post Graduation	16	10%
Graduation	110	73%
Intermediate	12	8%

Category-Awareness

The Awareness section of the questionnaire focused on a single dimension Knowledge measured through two items. The findings and analysis related to this dimension are presented below.



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Dimension- Knowledge of STEAM

As per the analysis, 52 per cent (n =72) participants were aware of the concept of STEAM (Fig. 2) while 28% (n=42) stated that they have heard about STEAM but are not fully aware. On the other hand, 9.3% (n=14) participants were aware of the science only and remaining 10.7% (n=16) were unaware of the concept of STEAM.

Are you familiar with the concept of STEAM?

150 responses

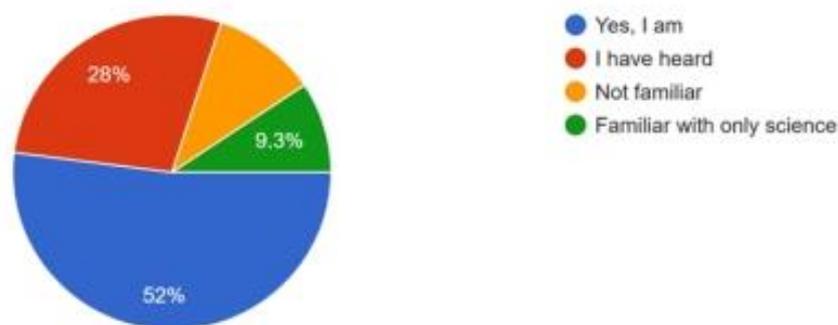


Figure 1: High school Students' Awareness about STEAM Education

As far as the beginning of STEAM education is concerned, 44.7% participants stated that STEAM education should start from middle school while 22.7% stated that it should begin from high schools. Among all the participants, 18.7% stated that STEAM education should be included from primary or early childhood level. Only 14% of the total participants stated that it should begin from university levels. As shown in Figure 2

At which educational level should STEAM education begin, in your opinion?

150 responses

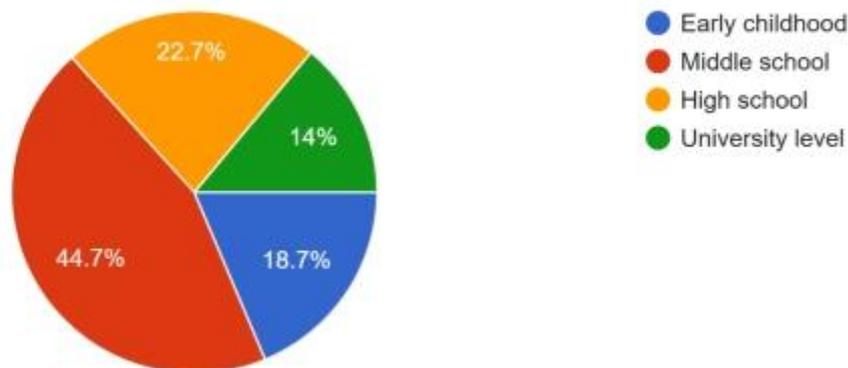


Figure 2: Perception Of Students To Introduce Steam Based Education At Schools



Category- perception

Dimensions-advantages of STEAM

The findings are shown in Figure of the first dimension viz. Advantages of STEAM-based education. The analysis of each item viz. (i) STEAM has made the learning process more engaging and interactive, (ii) STEAM encourages a holistic approach to understand the world, (iii) Using STEAM has improved the teaching-learning process by integrating various discipline and (iv) STEAM helps students acquire essential skills for the 21st century were included to know whether the students understand the advantages of STEAM or not.

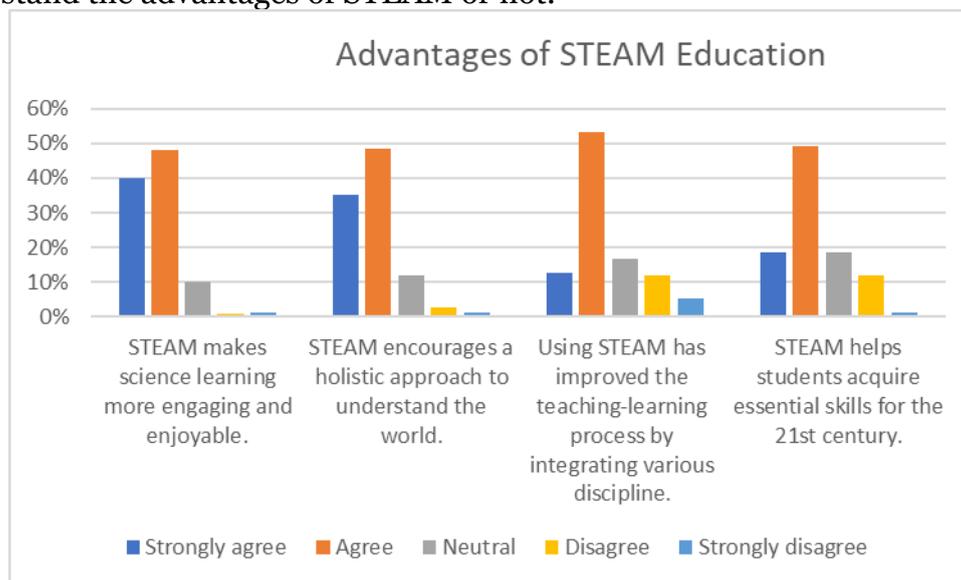


Figure 3: Perception of high school students on Advantages of STEAM Education

As per the analysis 88 per cent (n = 133), participating students also expressed that the learning process can be more interesting and interactive with STEAM, 84 per cent (n = 126) participants agreed on the notion that STEAM leads to holistic development in educational institutions, 66 per cent (n = 99) participants agreed upon the fact that STEAM has improved the teaching-learning process by integrating various and 68 per cent (n =102) participants agreed that STEAM helps students acquire 21st century skills.

Dimension- STEAM and Creativity

The findings are shown in figure 4 for the dimension, “Creativity and STEAM Education”. The analysis of each item i.e. (i) STEAM-based education can significantly enhance students' Creativity, (ii) The current curriculum in Pakistan’s schools promote creativity through STEAM activities, (iii) STEAM education encourage students to think outside the box and (iv)STEAM education can help bridge the creativity gap between private and public educational institutes in Pakistan, were included to know students’ perspective on the impact of STEAM education on their competitive skill.

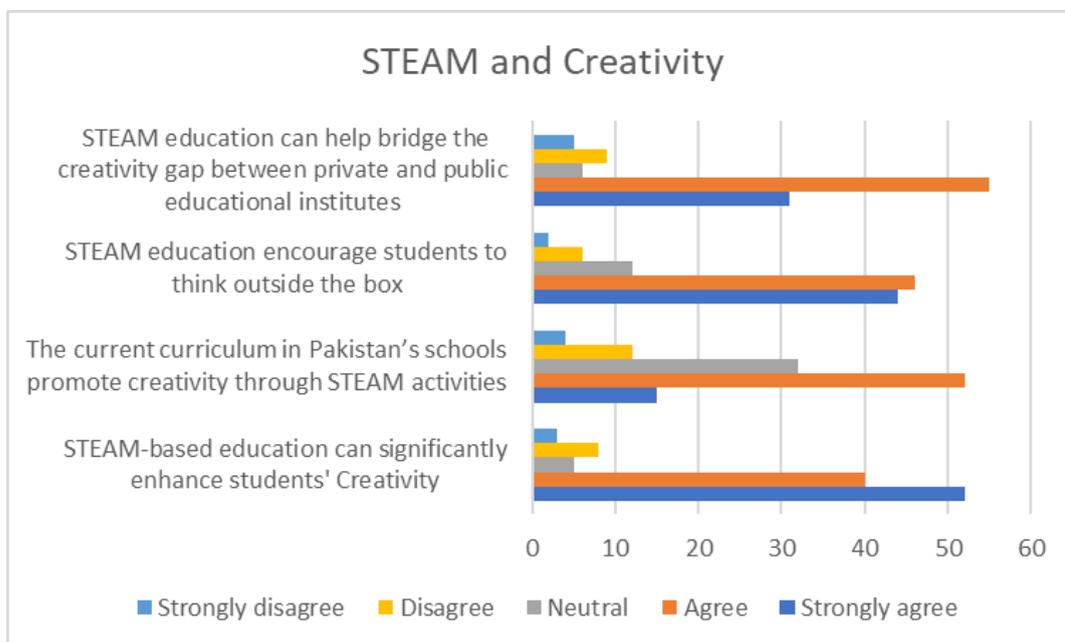


Figure 4. Effect of STEAM on Students’ Creativity

As per analysis 52% of the participants strongly agree and 39% were agree to the fact that STEAM based education can foster the sense of creativity in students. 50% of the participants were agreeing that the current curriculum of Pakistan supports STEAM education while for the third category, around 86% of the participants were agreeing with the fact that STEAM education makes students able to think outside of the box. On the other hand, around 82% of the participants believed that STEAM education is a renowned approach which can bridge the creativity gap among private and public-school students.

Category-Implementation

This category of the questionnaire was used to assess the implementation of STEAM based education in different educational institutions. This category included only one dimension with further four items. These items were (i) Are there sufficient resources available in your institution for implementing STEAM in science education?, (ii) How frequently are hands-on STEAM activities conducted in science classes in your institution?, and (iii) Do you believe STEAM-based science education can improve Pakistan's technological and scientific development? Findings of this category are shown below:



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Are there sufficient resources available in your institution for implementing STEAM in science education?

150 responses

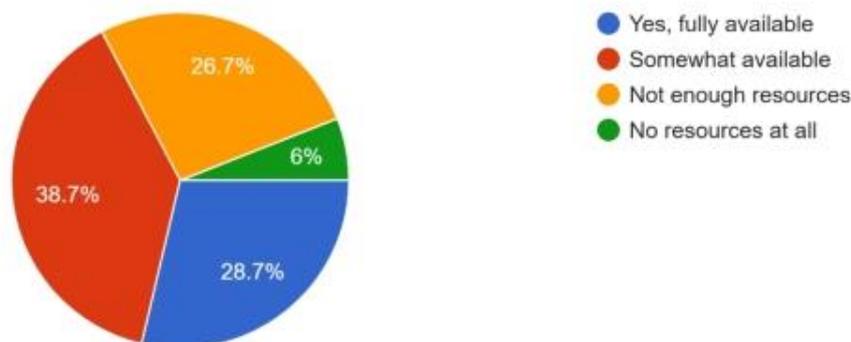


Figure 5. Resources available for STEAM training in Educational Institutions

As per analysis, 28.7% participants accepted the availability of resources for STEAM based education in their institutions while 38.7% said there are some resources available. On the other hand, 26.7% responded that they do not have enough resources to integrate STEAM based education and 6% of participants completely denied the presence of any resources.

How frequently are hands-on STEAM activities conducted in science classes in your institution?

150 responses

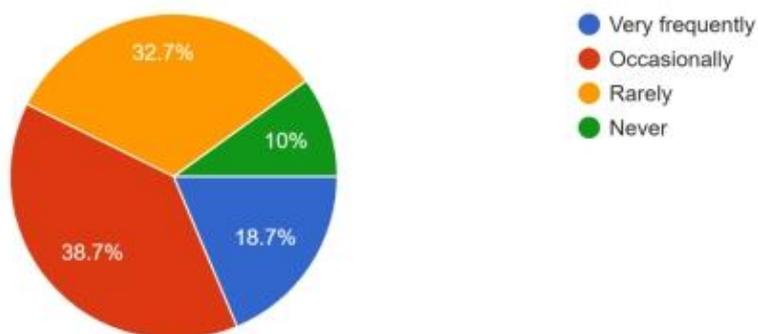


Figure 6. Percentage of Hands-on STEAM Activities in Science Classrooms

For the question, hands on STEAM activities conducted in science classes, only 18% stated that there are frequent ongoing trainings and activities while also 70% of the participants said they have very less STEAM based activities in their institutions. 10% of the participants agreed that they never had any STEAM based training or hands on activity in their institution.



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Do you believe STEAM-based science education can improve Pakistan's technological and scientific development?

150 responses

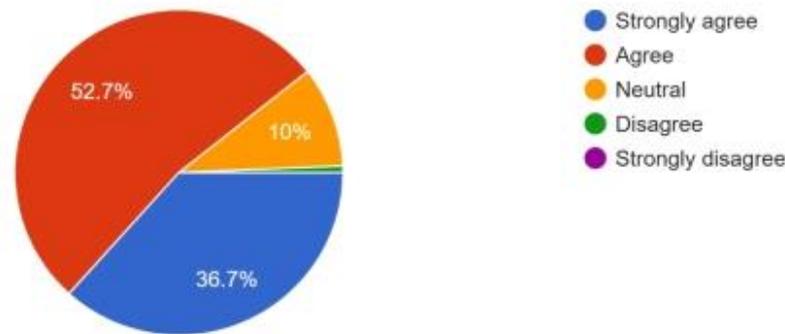


Figure 8. Scientific and Technological Development due to STEAM
Collectively around 88% participants were agree that STEAM-based education can improve the technological and scientific development in Pakistan.

Conclusion

The findings of this study reveal a promising yet uneven landscape for STEAM education in Pakistani science high level classrooms. A majority of students (over 70%) are aware of STEAM and recognize its advantages, including enhanced creativity, deeper understanding, critical thinking, and 21st-century skill development. Most students (88%) agreed that STEAM makes learning more interactive and holistic, while 86% acknowledged its role in promoting out-of-the-box thinking. However, a significant implementation gap was observed. Only 18% reported frequent hands-on STEAM activities in their institutions, and just 29% confirmed the adequate availability of resources. Despite these limitations, 88% believed it could contribute positively to Pakistan's scientific and technological progress. The data highlights a strong student perception of STEAM's educational value but a lack of institutional readiness and support for effective integration. Therefore, strategic interventions—such as teacher training, curriculum redesign, and resource allocation are crucial to bridge this gap and embed STEAM practices sustainably across educational levels.

Future Recommendations

Based on the study's findings, it is recommended that STEAM education be formally integrated into the national curriculum. Teacher training programs should be introduced to equip educators with the skills needed to implement interdisciplinary, creativity-focused teaching. Schools must be provided with adequate resources to support hands-on STEAM activities, particularly in public and under-resourced institutions. Efforts should also focus on reducing the gap between public and private schools through equitable support and awareness campaigns. Lastly, further research involving teachers and rural settings is essential to develop a more inclusive and practical STEAM implementation model.

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