www.idosr.org Geriga, 2025

©IDOSR PUBLICATIONS

ISSN: 2579-0773

International Digital Organization for Scientific Research IDOSRJAH11100
IDOSR JOURNAL OF ARTS AND HUMANITIES 11(1):19-24, 2025.
https://doi.org/10.59298/IDOSRJAH/2025/1111924

Implementing Steam Education: Challenges and Solutions

Geriga Manisuru

Department of Public Administration and Management Kampala International University Uganda

Email: Manisuru.geriga@studwc.kiu.ac.ug

ABSTRACT

As education evolves to meet the demands of a dynamic and interconnected global economy, the integration of the arts into STEM (Science, Technology, Engineering, and Mathematics) has given rise to STEAM education, a holistic pedagogical approach emphasizing creativity, critical thinking, and interdisciplinary learning. This paper examines the conceptual foundations, historical evolution, key components, and tangible benefits of STEAM education. It identifies critical challenges in its implementation, including structural limitations, teacher training gaps, assessment difficulties, and equity concerns. Drawing from empirical evidence and successful case studies, the paper proposes actionable solutions such as curriculum co-creation, real-world project integration, and enhanced professional development. By promoting collaborative, inquiry-based, and process-oriented learning, STEAM education prepares students not only for academic achievement but also for meaningful engagement in a rapidly changing world.

Keywords: STEAM Education, Interdisciplinary Learning, Creativity, Critical Thinking, Curriculum Reform, Educational Innovation, K–12, Pedagogy.

INTRODUCTION

As the world grows complex and demands for higher-order thinking increase, education systems must prepare students for 21st-century success. Traditional, one-size-fits-all instruction and rote memorization fail to equip students for a global economy. K-12 education must shift from standardized instruction to one that fosters critical thinking, problem-based learning, and collaboration. Neuroscience reveals that the arts, musical training, and movement enhance learning and brain development across all ages. Integrating the arts with all subjects in schools improves standardized test performance. In light of these critiques, school systems worldwide, including in the US, are re-evaluating curricula, practices, and assessment methods. Advances in science and technology have enriched early childhood arts education, even though further research is needed. However, important empirical findings now exist that can inform arts education across various sectors. The integration of literacy, phonetics, spelling, and artistic skills involves the coordination of phonological, motor, and visual skills, enhancing language comprehension. Investigating how language interacts with different representations is essential. STEAM education answers how disciplines can be better understood through art. A shift from product-based to process-based learning enhances how art relates to other subjects and informs teaching these disciplines through art. A process-oriented approach allows exploration of diverse subjects centered on art, creativity, and inquiry [1, 2].

Historical Context of Steam

The recent incorporation of art into STEM education, thereby creating STEAM education, has been a new concept in American education. STEM education refers to teaching and learning in the field of Science, Technology, Engineering, and Mathematics. Meanwhile, STEAM education adds art to the defined curricula, which uses the aspects of "creativity" and "design". Some states and organizations began to adopt STEAM education because of its intense focus on science and math literacy, along with the prediction that educated workers will dominate future American jobs. However, with the rise of a reaction and fast-paced information generation through computer contingencies, many educators have realized that "creativity" and "general knowledge" are elemental skills that have to be acquired through educational disciplines. Art is an educational discipline rooted in western values with its societal reference that upbringing creates ethics and design. In contrast, STEM education, which is information technology-oriented, is new in terms of historical context. The cultural reference to western culture is to develop through the imitation of referential forms before one can create new forms substantially. STEAM (STEM + Arts) education is not an absolute or essential educational model considered as a foundation for disciplinary building, requiring passive individual involvement. STEAM education does not exist separately but is always within multi-disciplinary fields through the interactive combination and mutual infiltration of disciplinary formats. With the rapid evolution of scientific technology, a design of education that mainly focuses on the existence and building of knowledge about the structure of nature to predict its operation in the real world has become unable to produce valid responses to a new mode of existence, an immediate impact, and a chaotic stream of information. Creativity has socio-political implications that cause the uproarious disruption of disciplinary formats regarding new forms of social production and social relations [3, 4].

Key Components of Steam

Due to rapid technological advancement, education systems must evolve to equip students with the necessary skills to navigate their world. Programs focusing on science, technology, engineering, and math (STEM), and incorporating art to create STEAM, can effectively engage students through active learning and collaboration. STEAM education teaches problem-solving, inquiry, teamwork, and presentation skills. With the need for increased student engagement, K-12 educators must adapt programs to incorporate STEAM. Parents and educators should recognize diverse communication methods children need to express their understanding of the world, offering varied academic choices for success. However, implementing STEAM education to enhance academic achievement, emotional intelligence, and innovation faces challenges like outdated curricula, budget constraints, and insufficient methods for STEAM disciplines. Many students contend with rigid educational structures that limit academic standards, creativity, and self-discovery opportunities. Additionally, schools often lack immediate access to technology, adequate teacher training, collaboration time, and maintain high teacher-student ratios, hindering the development of comprehensive STEAM programs and exposing students to its full benefits [5, 6].

Benefits of Steam Education

Even though STEAM education is still in its relatively early stage of implementation, students have already begun to reap the benefits of STEAM. Because STEAM education attempts to connect the dots between various subject areas, students have been engaged in a variety of subject-integrated activities. For instance, a recent study found that a teacher utilized cartooning, video editing, storyboarding, and modeling as methods of display in an environmental science literacy project. As a result, students became more aware of their environment, as well as how their actions either hindered or fostered its health. Likewise, students demonstrated the capability to create their well-planned multimedia presentations. Implementation of STEAM education is still in its relatively early stages, and many districts have not pursued a cohesive STEAM education initiative. However, many educators have begun to implement STEAM-based projects in their classes. For example, as presented in teacher accounts and reflections, students have engaged in robotics and 3D printing. Educators have witnessed huge advantages of STEAM education beyond content area mastery. Students have been more excited to learn information, develop problem-solving skills to arrive at the correct answer, become better team members in a collaborative working environment, become thoughtful thinkers, develop a greater pride in their work, and become better self-advocates in explaining their mistakes. Through preparation and reflection of STEAM activities, educators noted a deeper understanding of content across subjects, and students used academic vocabulary and made content connections. In addition to cognitive gains, the inclusion of STEAM education has aided in the development of the social-emotional functioning of students in a collaborative working environment. Through student accounts and reflection on projects, students learned to function as team members and develop individual team member expectations. Students learned to manage the risk of an unknown outcome, either failure or success, in their product creation. When students created products that truly expressed their ideas and thoughts regarding a topic, they had greater ownership and pride in their work at exhibiting and explaining the product [7, 8].

Critical Thinking Skills

Critical thinking is crucial for a complete education, essential for academic success, and global citizenship. It transcends individual subjects and serves as an interdisciplinary supplement, potentially alleviating funding issues in STEAM education by incorporating history and writing. In math, critical thinking enhances understanding and concept assimilation, while in Science, it promotes curiosity about the world. In Social Studies, it fosters analytical skills for complex situations, and in Language Arts, it enables powerful language use. Ultimately, critical thinking places facts within a broader human context, forming the foundation of education through strategies and questioning routines rooted in enlightenment methodologies. This focus should be consistent across ages and subjects, yet many educational settings neglect critical thinking, assuming it will develop naturally in subjects like Social Studies or Language Arts—a misguided belief that overlooks its importance. This oversight contributes to a blind spot in educating future generations. There is a concerning trend in education that sidelines critical thought, emphasizing the teaching of facts without contextual relevance. Analyzing information and developing new patterns to illustrate principles are essential to refining this approach [9, 10].

Collaboration and Communication

In STEAM education, achieving collaboration across disciplines is difficult due to differing perceptions. Collaborators often lack a shared vision, with academics viewing collaboration as a process and industry professionals considering it a communicative product. Communication is hindered by the absence of a common language, affecting technical disciplines more than conceptual ones in public engagement. Miscommunication stemming from disciplinary backgrounds and human-related factors complicates teamwork, as differences in knowledge and interpretation of abstract models arise. External factors like funding context exacerbate competition among collaborators, creating stress and tunnel vision from rigid funding requirements. Insufficient expertise can lead to inappropriate problem-solving approaches. Trust violations may occur due to differing cultural opinions or prejudices related to disciplinary affiliation. Prior projects should inform appropriate collaborative processes, emphasizing the importance of grasping the project at an abstract level before focusing on specifics. Establishing common ground is crucial for understanding expectations, while documenting internal dynamics and managing written references helps prevent misunderstandings. Developing a communication tool platform streamlines information and progress sharing, requiring only basic programming knowledge to enhance mutual understanding and clarify responsibilities. Onboarding procedures, such as reviewing literature and reports, are vital for familiarizing collaborators with past efforts [11, 12].

Creativity and Innovation

Creativity and innovation are closely linked concepts centered on creating new, valuable ideas. They are crucial for modern economies and societies, as well as vital components of 21st-century education. Creativity involves unique thinking, necessary for success in a dynamic and competitive global economy. This innovative capacity stems from creativity, entrepreneurial education, and talent development. As a significant educational focus, creativity is essential for personal and professional success. The 20th-century educational movements emphasized fostering creativity as vital for 21st-century education. Globalization and rapid technological changes necessitate new educational practices, particularly in large cities. STEAM education, which builds on STEM principles, emphasizes integrating the arts into learning. This approach nurtures interdisciplinary skills and long-term problem-solving abilities. As the 21st century evolves, STEAM education addresses these challenges by promoting collaboration across disciplines, essential for tackling complex problems [13, 14].

Challenges in Implementing Steam

Implementing STEAM education in K-12 institutions presents challenges for educators and administrators. Interviews were conducted with K-12 STEAM educators in Connecticut to identify barriers to curriculum implementation, categorized as pedagogical, curricular, structural, student concerns, assessment concerns, and teacher supports. Specific solutions to these challenges include allowing teachers to co-create curriculum rather than relying solely on pre-developed sources, encouraging cross-curricular collaboration, and incorporating teacher input in assessments, including teacher-created rubrics for accurate student progress evaluation. Providing STEM-specific professional development time is essential for teachers to implement their curriculum effectively and benefit both educators and students. While STEAM education is widely regarded as beneficial, the best implementation strategies remain unclear, with many educators inexperienced in this pedagogical approach. Effective implementation of STEAM requires support from both educators and administrators, particularly as this educational area expands. Properly executed, STEAM education can enhance students' futures by fostering creativity, critical thinking, collaboration, and communication skills while igniting a passion for inquiry and problem-solving. Since 2004, STEM has been recognized as a vital educational component worldwide, with a critical need for a skilled workforce in STEM fields persisting over a decade later. There are concerns among educators regarding widening gaps in gender, ethnic, and socio-economic representation in STEAM fields. Curriculum expansion offers a promising avenue to deliver and improve STEM education in schools. A recent surge of STEM education has been observed globally, allowing students to collaborate and integrate learning across various subjects. However, significant challenges persist for those tasked with implementing STEM education in K-12 schools [15, 16].

Solutions To Overcome Challenges

As society advances into the 21st century, the demand for a workforce with critical and creative thinking skills is essential for economic, political, and cultural progress. Despite the high number of engineering and technology graduates in the U.S., there remains a shortage of Crystal Engineers, product designers, and animators. To address this gap, schools are increasingly adopting process-based education, with STEAM education offering a path to cultivate these skills and foster innovation. Although a new educational approach, STEAM can be enhanced through various methods to engage and educate students, improve learning, and nurture critical thinkers for the future. Recommendations include integrating real-world products instead of merely completing assignments, focusing on self-driven, multi-week projects rather than traditional content-focused units, and implementing project-based learning across all assignments. Engaging students through real-world products fosters ownership and investment in their education, leading to genuine engagement. By allowing students to participate in the creation process, share their work, and receive peer feedback, they develop competencies that prepare them for adulthood. Projects such as building a functional bridge or developing product packaging not only teach essential mathematics and core content but also instill a sense of purpose, encouraging students to perceive their work as valuable. Such engagement cultivates functional literacy within the learning process [17, 18].

Case Studies of Successful Steam Programs

Public schools in Colorado convened at Campbell Elementary, known for its successful STEAM initiative. Observations revealed that the initiative encompassed more than just new classes; it involved a holistic transformation of the school environment. The inviting building featured artwork embodying creative research, with interdisciplinary connections woven throughout the curriculum. Learning spaces were adaptable, promoting creativity and collaboration. Students had the freedom to choose materials, fostering a respectful and innovative community. Collaboration was evident not only among teachers but also with the broader community, including local businesses and technologists. This included collective feedback and diverse perspectives. Hewes aimed to explore Campbell's STEAM curriculum successes to inspire her K-8 school's future. Reflecting on Campbell's two years of development, she noted meaningful professional growth through informal discussions among educators. Campbell's model served as a framework for other schools to facilitate documentation and collaboration, promoting sustained curriculum opportunities. General assessment themes helped other schools share successes. For Hewes and her colleagues, Campbell Elementary provided a structure for their ideas and reflections, encouraging adaptation instead of direct replication while promoting the incubation of new ideas within their culture [19, 20].

Role of Technology in STEM Education

Technology has transformed the roles of teachers and students in classrooms. It enables students to creatively understand course material and allows teachers to integrate media design programs, enhancing critical evaluation of art, science, math, and engineering through design processes. For instance, art students utilized a 3D scanner and ZBrush to explore microscopic structures, proposing research on nanoparticles for drug treatments. 3D printing offers diverse options for learning and demonstrating concepts, surpassing traditional materials like books. It allows students to design, test, and share 3D models, fostering a deeper grasp of physical concepts. Science students can print designs, converting simple drawings into testable shapes using various materials. For engineering students, graphic chairs are 3D printed based on collected data and ergonomic comparisons. This hands-on experience aids students in correcting or reinforcing their assumptions. The dynamics in schools have shifted; students are now central to learning, with teachers guiding rather than lecturing. A successful STEAM program requires adequate support and budget. Effective use of search engines can assist school districts in understanding their technology needs, including average daily use and access requirements for digital devices. Through creative projects like designing buildings or a Chase Bank, students can foster artistic skills and expand classroom knowledge [21, 22].

Future Trends in Steam Education

As STEAM education evolves, global trends are emerging, particularly supported by policies in Asia, Europe, and North America, with Taiwan as a notable example. K-12 teachers are increasingly utilizing diverse materials and collaborative platforms in STEAM education. To align with educational policies, STEAM educators and tech developers are creating opportunities for effective learning. A blend of direct and indirect pedagogies is essential for varying contexts within STEAM education. Adapting STEM to different societies requires diverse perspectives, maintaining dynamic and participatory approaches for effectiveness. Key skills for implementing STEAM education include art and design knowledge among educators to enhance design learning and STEM integration in art. Pedagogical and didactic skills need to improve to innovate learning experiences. Collaboration across regions in teacher education is vital for professional development. Emphasizing inquiry is necessary to meet diverse aspirations. Cross-national partnerships, electronic platforms, and semi-official accreditation are recommended for teacher education in Southeast Asia. Developing pre-service education for interdisciplinary STEAM instruction tailored to cultural norms in Asia and Europe enhances the relevance of STEM disciplines [23-26].

CONCLUSION

STEAM education presents a transformative opportunity to reimagine learning in the 21st century by merging creativity with scientific and technological inquiry. While its implementation in K–12 schools encounter numerous barriers, including outdated structures, insufficient training, assessment inconsistencies, and inequitable access, these challenges are not insurmountable. Solutions such as real-world, project-based learning, curriculum co-design, and teacher collaboration have shown promise in overcoming these obstacles. The success of model institutions like Campbell Elementary demonstrates that a holistic, student-centered approach fostered through adaptive environments and community partnerships can elevate both educational outcomes and learner engagement. To ensure the sustainability and effectiveness of STEAM initiatives, stakeholders must invest in continuous professional development, foster interdisciplinary communication, and promote a culture of innovation. Ultimately, STEAM education is not just a pedagogical trend; it is a vital framework for equipping students with the tools to thrive in a complex, rapidly evolving world.

REFERENCES

1. Burnaford GE, Aprill A, Weiss C, editors. Renaissance in the classroom: Arts integration and meaningful learning. Routledge; 2013 Sep 5.
2. Elpus K. Access to arts education in America: The availability of visual art, music, dance, and theater courses in US high schools. Arts Education Policy Review. 2022 Jan 20;123(2):50-69.
3. Belbase S, Mainali BR, Kasemsukpipat W, Tairab H, Gochoo M, Jarrah A. At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. International Journal of Mathematical Education in Science and Technology. 2022 Oct 3;53(11):2919-55. tandfonline.com
4. Ortiz-Revilla J, Greca IM, Arriassecq I. A theoretical framework for integrated STEM education. Science & Education. 2022 Apr;31(2):383-404.
5. Milara IS, Orduña MC. Possibilities and challenges of STEAM pedagogies. arXiv preprint arXiv:2408.15282. 2024 Aug 21.
6. Voicu CD, Ampartzaki M, Dogan ZY, Kalogiannakis M. STEAM implementation in preschool and primary school education: Experiences from six countries. InEarly Childhood Education-Innovative Pedagogical Approaches in the Post-Modern Era 2022 Oct 23. IntechOpen.
7. Marín-Marín JA, Moreno-Guerrero AJ, Dúo-Terrón P, López-Belmonte J. STEAM in education: a bibliometric analysis of performance and co-words in Web of Science. International Journal of STEM Education. 2021 Jun 25;8(1):41. springer.com
8. Boice KL, Jackson JR, Alemdar M, Rao AE, Grossman S, Usselman M. Supporting teachers on their STEAM journey: A collaborative STEAM teacher training program. Education Sciences. 2021 Mar 5;11(3):105. mdpi.com
9. Hunter BE. Focus on critical thinking skills across the curriculum. Nassp Bulletin. 1991 Feb;75(532):72-6.
10. Ye P, Xu X. A case study of interdisciplinary thematic learning curriculum to cultivate "4C skills". Frontiers in Psychology. 2023 Mar 7;14:1080811.
11. Kim J, Yu S, Detrick R, Li N. Exploring students' perspectives on Generative AI-assisted academic writing. Education and Information Technologies. 2025 Jan;30(1):1265-300.
12. Hu Y, Fang S, Lei Z, Zhong Y, Chen S. Where2comm: Communication-efficient collaborative perception via spatial confidence maps. Advances in neural information processing systems. 2022 Dec 6;35:4874–86. neurips.cc
13. Graefe AK, Omdal SN. Investing in creativity in students: The long and short (term) of it. InCreativity and Innovation 2022 Mar 14 (pp. 189-208). Routledge.
14. Graefe AK, Omdal SN. Investing in creativity in students: The long and short (term) of it. InCreativity and Innovation 2022 Mar 14 (pp. 189-208). Routledge.
15. Ogenyi FC, Eze VH, Ugwu CN. Navigating Challenges and Maximizing Benefits in the Integration of Information and Communication Technology in African Primary Schools.

International Journal of Humanities, Management and Social Science (IJ-HuMaSS). 2023 Dec 20;6(2):101-8.
16. Anteliz EA, Mulligan DL, Danaher PA, editors. The Routledge international handbook of autoethnography in educational research. Routledge; 2022 Nov 10.
17. Öztürk A. Meeting the Challenges of STEM Education in K-12 Education through Design Thinking. Design and Technology Education. 2021 Feb;26(1):70-88.
18. Laksmiwati PA, Lavicza Z, Cahyono AN. Empowering STEAM Learning Implementation through Investigating Indonesian Teacher Expertsâ€™ Views with a Delphi Method. Indonesian Journal on Learning and Advanced Education (IJOLAE). 2024;6(2):214-29. ums.ac.id
19. Mang HM, Chu HE, Martin SN, Kim CJ. An SSI-based STEAM approach to developing science programs. Asia-Pacific Science Education. 2021 Dec 9;7(2):549-85.
20. DeAngelis AM. The Future of Education: STEAM Programs in K-20 Schools. Drexel University; 2017.
21. Eze VH, Eze CE, Mbabazi A, Ugwu CN, Ugwu PO, Ogenyi CF, Ugwu JN, Alum EU, Obeagu EI. Qualities and Characteristics of a Good Scientific Research Writing; Step-by-Step Approaches. IAA Journal of Applied Sciences. 2023;9(2):71-6.
22. Long II RL, Davis SS. Using STEAM to increase engagement and literacy across disciplines. The STEAM Journal. 2017;3(1):7.
23. Razi A, Zhou G. STEM, iSTEM, and STEAM: What is next?. International Journal of Technology in Education. 2022;5(1):1. uwindsor.ca
24. Diego-Mantecon JM, Prodromou T, Lavicza Z, Blanco TF, Ortiz-Laso Z. An attempt to evaluate STEAM project-based instruction from a school mathematics perspective. ZDM–Mathematics Education. 2021 Oct;53(5):1137-48. springer.com
25. Mou L. Exploring liberal arts education in the twenty-first century: Insights from East Asia, North America, and Western Europe. Annual Review of Comparative and International Education 2020. 2021 Aug 2:127-47. researchgate.net
26. Park W, Cho H. The interaction of history and STEM learning goals in teacher-developed curriculum materials: opportunities and challenges for STEAM education. Asia Pacific Education Review. 2022 Sep;23(3):457-74.

CITE AS: Geriga Manisuru (2025). Implementing Steam Education: Challenges and Solutions. IDOSR JOURNAL OF ARTS AND HUMANITIES 11(1):19-24. https://doi.org/10.59298/IDOSRJAH/2025/1111924