Article

Forum for Education Studies 2024, 2(3), 1430.
https://doi.org/10.59400/fes.v2i3.1430

Integrating STEAM education in the school science teaching at Gorkha district

Kamal Prasad Koirala[1,*], Krishna Prasad Parajuli[2]

[1] Central Department of Education, Tribhuvan University, Kathmandu 44600, Nepal
[2] Tribhuvan University, Drabya Shah Multiple Campus, Gorkha 34000, Nepal
*** Corresponding author:** Kamal Prasad Koirala, koiralakamal36@gmail.com

CITATION

Koirala KP, Parajuli KP. Integrating STEAM education in the school science teaching at Gorkha district. Forum for Education Studies. 2024; 2(3): 1430. https://doi.org/10.59400/fes.v2i3.1430

ARTICLE INFO

Received: 5 June 2024
Accepted: 17 June 2024
Available online: 18 July 2024

Abstract: This article explores the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education into the secondary school science curriculum. It provides an in-depth analysis of the current state of STEAM education, challenges, successes, and future directions. The article draws on literature reviews, theoretical frameworks, and interviews with science teachers to offer a holistic view of the benefits of STEAM education integration at school-level science teaching. This study was carried out by selecting three schools in the Gorkha district and three science teachers who are implementing separate types of STEAM-based project approaches in science teaching. This study found that science teachers attempted to implement the project-based technology-friendly STEAM approach in their classrooms. However, they faced several obstacles to the integration of STEAM into the present school science curriculum due to the limited availability of internet facilities. It suggests that policy level and curriculum designers prepare the STEAM-based curricula for transdisciplinary (STEAM-based) school science teaching.

Keywords: STEAM education; creative thinking; constructive learning; science teaching

1. Introduction

STEAM education has emerged as a transformative approach to learning [1] to bridge the gap between theoretical knowledge and practical application in school science teaching [2]. The present school science teaching includes mainly science and technology areas in the curriculum. However, it has seen included engineering mathematics and creativity-related arts also. The socioculturally generated knowledge can be included within the STEAM-based curriculum which enhances the holistic knowledge of learners [3]. Integrating STEAM into the school science curriculum is crucial for fostering a generation of students equipped with critical thinking, problem-solving, creative skills, computation skills and communication skills essential for the 21st-century workforce [2,4]. It is justified by Dacumos [5] arguing that project-based STEAM learning, is a student-driven approach that emphasizes hands-on, inquiry-based projects to solve real-world problems, promotes active and engaging learning, collaboration, community building, and the development of critical thinking, problem-solving, creativity, and communication skills. Park et al. [6] viewed the inclusion of artificial intelligence as an innovation that supports the implication of STEAM-based teaching in the science classroom. Considering the above context, this article aims to analyze the integration of STEAM education within the school science curriculum, highlighting its significance, current challenges, and future potential.

2. Literature review

2.1. The evolution of STEAM education

STEAM education, evolving from the STEM (Science, Technology, Engineering, and Mathematics) framework, incorporates the arts to foster creativity and lifelong education for the holistic learning of students [7]. According to Yakman [7], the incorporation of arts in STEAM education enhances students' ability to connect interdisciplinary, multidisciplinary and transdisciplinary knowledge and apply it in real-world contexts. It is justified by Johnson and Czerniak [8] saying that the interdisciplinary approach supports the integration of STEAM at the school science teaching. This integrative approach is designed to break down traditional subject boundaries, encouraging a more cohesive understanding of complex concepts.

2.2. Theoretical bases for supporting STEAM integration

Vygotsky's [9] social constructivist theory emphasizes the importance of social interactions in learning, which aligns well with STEAM's collaborative nature. Vigotsky's learning idea is knowledge construction participating in the social phenomenon which ultimately supports the project-based integrated teaching. Similarly, Piaget's theory of cognitive development supports the hands-on, inquiry-based learning model that STEAM education promotes. Integrated and STEAM approaches are based on the theory of socio-constructivism, inquiry learning and context-based pedagogy [10]. These theories support the importance of integrating multiple disciplines to enhance the cognitive development and problem-solving skills of the learners based on the cultural context of learners which ultimately supports the decolonization of the present context of school science teaching [11,12].

2.3. Benefits of STEAM education

Research indicates that STEAM education fosters higher-order thinking skills, creativity, and innovation [13]. Students engaged in STEAM activities demonstrate improved problem-solving abilities, critical thinking, and teamwork [14,15]. Additionally, integrating the arts into STEM subjects helps in developing emotional intelligence and cultural awareness, providing a well-rounded transdisciplinary education which focuses on 3D knowledge for students [16].

2.4. Challenges in implementing STEAM education

Despite its benefits, the implementation of STEAM education faces several challenges. Lack of resources, insufficient teacher training, and rigid curriculum structures are significant barriers [17]. In many regions, especially in developing countries, economic and infrastructural constraints further hinder the effective integration of STEAM education [18].

2.5. Current state of STEAM education integration

2.5.1. Curriculum design and structure

The integration of STEAM education into the secondary school curriculum requires a well-structured design that allows for interdisciplinary learning. According to Bybee [17], successful STEAM programs involve project-based learning, where students engage in complex, real-world problems that require knowledge from multiple disciplines. This approach not only makes learning more relevant but also helps in retaining students' interest and engagement.

2.5.2. Teacher training and professional development

Effective STEAM education necessitates that teachers are well-trained and comfortable with the interdisciplinary nature of STEAM subjects. Professional development programs focusing on STEAM education are essential for equipping teachers with the necessary skills and knowledge. As highlighted by Darling-Hammond et al. [19], ongoing professional development is crucial for the successful implementation of STEAM education. However, in the context of Nepal, adequate professional development practice could not be seen applied to school science teachers.

2.5.3. Resource allocation and infrastructure

Adequate resources and infrastructure are crucial for STEAM education. This includes access to laboratories, technological tools, and materials that facilitate hands-on learning. In many schools, especially in remote areas, the lack of such facilities poses a significant challenge to the implication of STEAM education [17]. Collaborative efforts between schools, communities, and policymakers are essential to address these resource gaps.

2.5.4. Community and industry partnerships

Partnerships with local communities and industries can enhance STEAM education by providing students with real-world experiences and resources. According to Hynes et al. [20], such collaborations can offer students opportunities for internships, mentorships, and exposure to various STEAM fields, making learning more practical and applicable. However, in our context, such types of collaboration between different stakeholders have not been properly applied.

3. Methodology

This study follows the qualitative case study design. In this study, three schools were selected purposively in the Gorkha district in Nepal. Out of three schools, the first school was a basic school which ran classes up to Grade Eight. The second school ran classes up to Grade Ten. The third school ran classes up to Grade Twelve. These three schools represent the three different areas of Gorkha district which have enthusiasm to apply STEAM knowledge at the school level. Those science teachers who were creative and dynamic in applying STEAM knowledge to their teaching were purposively selected as the participants for this study. All of the participants had 10–15 years of teaching experience at different schools. One of the participants was female who was teaching science at basic level school. Other two participants were males who were teaching at secondary schools. Interview guidelines were prepared to find out the teachers' views based on the challenges, opportunities and constraints to applying integrated STEAM education at the school level. Similarly, classroom observation guidelines were prepared to see their knowledge practice in the classroom. Three classroom observations and interviews were conducted with each science teacher to find out the learning context of STEAM in the school education system. The collected data were transcribed, translated and coded to find out the themes relating to STEAM-based science teaching. The themes were based on implementation strategy and challenges faced by the teachers for the application of STEAM knowledge at the school level. Verbal consent was taken by both headteachers and teachers for the collection of data. For ethical considerations, we used pseudonyms of school and teachers.

4. Findings of the study

4.1. Shree Himalaya Secondary School (pseudonyms)

4.1.1 Background

Shree Himalaya Secondary School, located in Barpak Sulikot Rural Municipality of Gorkha district, has recently initiated a project-based approach within its science curriculum at Grade Eight. The curriculum aims to enhance students' learning experiences by incorporating interdisciplinary projects and hands-on activities while teaching science content. The science teacher who is teaching at Grade Eight applied project work on water filtration systems based on the filtration chapter of Grade Eight. There were students from diverse sociocultural background in the classroom. Students were actively involved in the project work that was provided by science teachers. In the classroom students developed the project how to filter and purify water. Science teacher supported their students for hand on experimental knowledge.

4.1.2. Implementation strategy

The school introduced project-based learning modules where students worked on real-world problems, integrating science, technology, engineering, arts, and mathematics. For instance, students designed a water filtration system using locally available materials, combining concepts from physics, chemistry, mathematics, technology and environmental science in the classroom. The science teacher supported students to use the STEAM knowledge while preparing the water filter. Ram (pseudonyms) reflected, "*Whenever he used the students in creative and critical learning practice based on project work provided in the science curriculum, it helped to develop the STEAM knowledge*". He added "*If teachers provide the learning opportunities to the students, they can create the learning culture at school as well as in their house and prepare a good model and demonstrate at the classroom. It makes us easy to provide the concept of STEAM whenever they actively work in the project work*". The classroom observation showed that whenever students focus their learning on project work, they developed the knowledge of creativity, critical thinking, and collaborative learning which ultimately supports to develop the STEAM knowledge. Whenever we observed their classes, they were making water filtration using the locally available pots.

4.1.3. Challenges and outcomes

One of the significant challenges faced by the school science teacher was the lack of resources and training opportunities. However, with support from local

NGOs and community involvement, the school managed resources to overcome some of these obstacles. In this context school science teacher said, "*We have a lab and some materials for doing project work prescribed in the curriculum but these are not sufficient to conduct all selected project work. We mostly apply the local material whenever doing the project work at school. I used to take students to local houses to see how they applied the filtering process of their drinking water*". He argued that, "*If students were not active in the project work and their parents did not support to prepare the local materials for them, it becomes difficult to apply at the classroom. However, I used to request students to convince their parents to support their children*". Whenever I observed his class, I found that he was explaining local technology and students were improving their problem-solving skills, and showing a greater interest in science subjects.

4.2. Shree Gorakhkali Basic School (pseudonyms)

4.2.1. Background

Shree Gorakhkali Basic School is situated in Gorkha Municipality. It has been a pioneer in integrating arts into its science curriculum, emphasizing the importance of creativity in learning. In this school, both headteachers and teachers were enthusiastic to apply the art-integrated STEAM approach in teaching-learning processes. Through the creativity, collaboration, communication and constructive learning environment at school, they attempted to incorporate STEAM knowledge into the school system.

4.2.2. Implementation strategy

The school developed interdisciplinary projects that required students to apply their knowledge in creative ways. An example includes a project where students created art pieces representing scientific concepts, such as the students drawing the figure of seven colours of the rainbow on paper, writing the colour of each of them as the project work and they demonstrated in the class and posted on the school wall. Those students' works indicate that they have developed the knowledge of the STEAM approach while learning the science in the integrated form. Grade Five students of the schools presented this project work of science. In this context science teacher argued that, "*If we supported the students to do project work based on their daily problem, they can easily apply them through which we can develop the holistic knowledge to the students*". He further argued that, "*Whenever I supported the students to prepare the rainbow in the chart paper, they prepared it well and I have posted their critical work at the wall which, you can see here*". Whenever students prepare the seven colors of the rainbow, they understand the science, engineering, mathematics, art and technology knowledge through their new knowledge creation activity. The classroom observation found that there were different types of student creation posted on the wall of the school. It indicated that the creative work of the students supports the implementation of STEAM knowledge.

4.2.3. Challenges and outcomes in the classroom

The main challenge was convincing stakeholders of the importance of integrating arts into the science curriculum. Whenever teacher ordered their students to bring the required materials from their homes, however, most of the parents showed their reluctance to support their children. However, through continuous dialogue and showcasing the benefits of a STEAM approach, the school gained support from the parents. In this case, Hari (pseudonyms) said that, "*Whenever we collect the parents of the students and request to them for support for their children's creative work at home, most of the parents were supported in the preparation of different types of learning material to their children*". Those creative works led to a deeper understanding of scientific concepts and enhanced students' creative and critical thinking skills. Whenever we observed some classes, students brought artistic materials prepared at their homes. One student prepared a plough at home with the support of his parents. It indicates that if teachers convince, parents they can support the creative work of students which ultimately supports gaining STEAM knowledge towards students.

4.3. Shree Bhakari Secondary School (pseudonyms)

4.3.1. Background

Shree Bhakari Secondary School is situated in Shahid Lakhan Rural Municipality. It has an enthusiastic secondary-level science teacher with good technological knowledge. He focuses on integrating technology and engineering into his science teaching to prepare students for future technological advancements. He used to take his students to provide the technological knowledge to advance the knowledge horizon of the students. In my observation I found that, he applied the technology-based simulated approach in science teaching in his classroom. In his simulated teaching students were excited to learn new things through the technology. The school had technology friendly learning environment and headteacher was supporting their teaching and learning science with integrated approach.

4.3.2. Implementation strategy

The school science teachers introduced simulation and gaming while teaching the technology part in Grade Nine, allowing students to build and program the simulation as part of their science projects in the classroom. This hands-on approach aimed to develop technical skills and foster an interest in engineering and technology to the secondary level students. In this context, Shyam (pseudonyms) said, "*Whenever I apply simulated science teaching in the classroom, it helps to develop the science, technology, engineering and mathematical ideas in a holistic form and generated new knowledge to teach the human heart through simulation process*". From this project work, students easily got the knowledge of how the human heart works. Headteachers were happy when science teacher used technology to teach the science in the classroom. In this context, Raman (pseudonyms) said, "*If we can apply such types of learning scenarios in the other classes, our all teaching learning will be effective and all the students will be engaged in the project-based learning as mentioned in the curriculum*". This indicates that STEAM-based simulated teaching enhances the cognitive learning of students as stated by Piaget.

4.3.3. Challenges and classroom outcomes

The lack of access to advanced technology and resources was a significant challenge to apply STEAM education while teaching science at secondary school. However, partnerships with NGOs, and local government can provide the necessary tools and expertise to the school and science teachers. In this context, the teacher said, "*We had an internet problem in the past but now a local NGO supported us to connect the internet at school. So, we have access to the internet every time at school. My staff and students can learn new things at the computer lab*". This comment indicates that technology-friendly classrooms result in high levels of student engagement, improved technical skills, and a keen interest in pursuing careers in technology and engineering for the learners.

5. Discussion and implications

The integration of STEAM education in the school science curriculum presents numerous benefits, including enhanced critical thinking, creativity, and problem-solving skills [3]. However, successful implementation requires addressing several challenges, such as resource allocation, teacher training, and curriculum design. The case studies from the Gorkha district illustrate both the potential and the obstacles to integrating STEAM education at the secondary level. For the effective implication of the STEAM approach, there should be adequate resources and funding for STEAM programs in schools, ensuring access to necessary materials and infrastructure. School teachers should get the opportunities for continuous professional development to apply STEAM subjects, focusing on interdisciplinary teaching methods and hands-on learning for transformative learning [1,2]. Developing flexible curriculum structures that allow for project-based learning from interdisciplinary to transdisciplinary art-based learning is necessary to make education more relevant and engaging for students [15]. Such curriculum systems foster partnerships with local communities and industries to provide students with real-world experiences and resources, enhancing the practicality of STEAM education.

The school science teacher of Bhakari Secondary School had more technology knowledge than the other two school science teachers. He applied the simulated teaching technology in science subjects. The science teachers of Gorakhkali school also used technology which was local art-based and it helped to develop creativity, critical thinking and constructive knowledge [3] that also ultimately supported the development of STEAM knowledge. Himalaya Secondary School also prepared a water filter model as the creative work at school which supported transformative learning of school as mentioned by Koirala [1]. As mentioned by Vygotsky [9], if we supported the knowledge construction process of students through interaction with their peers, they can develop constructive knowledge which ultimately supports to develop the STEAM-based integrated knowledge as argued by Shrestha and Panta [18]. So, artistic and creative learning supports the development of STEAM-based learning for science teachers.

This study can imply developing the art and technology-based curriculum at the school level. Whenever art and technology are embedded in the science curriculum, it supports creative, constructive and student-friendly teaching in the classroom. Art and technology-based teaching support the implication of the STEAM approach in the classroom [2]. So, the implication of STEAM-based teaching is crucial for providing 21st-century skills and competencies to learners.

6. Conclusion

The integration of STEAM education into the school science curriculum holds significant promise for enhancing students' learning experiences and preparing them for future challenges. While there are notable challenges, the benefits of a STEAM approach are fostering critical thinking, creativity, and problem-solving skills as well as technology-friendly teaching in the classroom. By addressing the community and society partnerships, science can successfully implement STEAM education, ultimately contributing to a more innovative and skilled workforce for the society. Whenever we use local artistic and modern technology in our classroom teaching, those technologies support the development of STEAM knowledge for the learners.

Author contributions: Conceptualization, KPK and KPP; methodology, KPK; software, KPK; validation, KPK and KPP; formal analysis, KPK; investigation, KPK; resources, KPK; data curation, KPK; writing—original draft preparation, KPK; writing—review and editing, KPK, KPP; visualization, KPK; supervision, KPK, KPP; project administration, KPK; funding acquisition, KPK. All authors have read and agreed to the published version of the manuscript.

Funding: Our gratitude goes out to the University Grants Commission, Nepal, for awarding the Small Research Development and Innovation Grant (Award No. SRDIG-79/80-Edu-01).

Acknowledgments: We extend our gratitude to science teachers who are teaching at different schools and contributed to this study.

Conflict of interest: The authors declare no conflict of interest.

References

1. Koirala KP. Transformative and equitable science teaching in the culturally diverse classroom: application of formative assessment system. International Journal of Science Education. 2024; 1-20. doi: 10.1080/09500693.2024.2356899
2. Koirala KP, Neupane N. Headteachers' understanding on STEAM-based integrated curriculum practice in Nepal. Discover Education. 2023; 2(1). doi: 10.1007/s44217-023-00056-9
3. Koirala KP. Science Teaching in Culturally Diverse Classrooms: Application of Sociocultural Knowledge at a School System in Nepal. Journal of Science Teacher Education. 2023; 34(5): 544-562. doi: 10.1080/1046560x.2023.2206693
4. DeCoito I, Myszkal P. Connecting Science Instruction and Teachers' Self-Efficacy and Beliefs in STEM Education. Journal of Science Teacher Education. 2018; 29(6): 485-503. doi: 10.1080/1046560x.2018.1473748
5. Dacumos LP. STEM education and the project-based learning: A review article. STEM Education Review. 2023. doi: 10.54844/stemer.2023.0385
6. Park J, Teo TW, Teo A, et al. Integrating artificial intelligence into science lessons: teachers' experiences and views. International Journal of STEM Education. 2023; 10(1). doi: 10.1186/s40594-023-00454-3
7. Yakman G. STEAM education: An overview of creating a model of integrative education. Purdue University Press; 2008.
8. Johnson CC, Czerniak CM. Interdisciplinary approaches and integrated STEM in science teaching. In: Handbook of Research on Science Education. Routledge; 2023. pp. 559-585.
9. Vygotsky LS. Mind in Society: The Development of Higher Psychological Processes. Harvard University Press; 1978.
10. Upadhyay B, Atwood E, Tharu B. Antiracist Pedagogy in a High School Science Class: A Case of a High School Science Teacher in an Indigenous School. Journal of Science Teacher Education. 2021; 32(5): 518-536. doi: 10.1080/1046560x.2020.1869886

11. Held MBE. Decolonizing Research Paradigms in the Context of Settler Colonialism: An Unsettling, Mutual, and Collaborative Effort. International Journal of Qualitative Methods. 2019; 18: 160940691882157. doi: 10.1177/1609406918821574
12. Koirala KP. Socio-culturally Embedded Vedic and Ethnoecological Knowledge: Decolonising Perspectives and Practices. Scholars’ Journal. 2021; 240-249. doi: 10.3126/scholars.v4i1.42483
13. Beers SZ. 21st Century Skills: Preparing Students for Their Future. University of Phoenix; 2011.
14. Quigley CF, Herro D. STEAM education: Descriptions, elements, and the creative learning process. Journal of STEM Education: Innovations and Research. 2016; 17(2).
15. UNICEF. Reimagining life skills and citizenship education in the Middle East and North Africa: A four-dimensional and systems approach to 21st century skills. Available online: https://www.unicef.org/mena/media/6151/file/LSCE%20Conceptual%20and%20Programmatic%20Framework_EN.pdf%20.pdf (accessed on 24 March 2024).
16. Liao C. From Interdisciplinary to Transdisciplinary: An Arts-Integrated Approach to STEAM Education. Art Education. 2016; 69(6): 44-49. doi: 10.1080/00043125.2016.1224873
17. Bybee RW. The case for STEM education: Challenges and opportunities. National Science Teachers Association Press; 2013.
18. Shrestha R, Pant B. Challenges in implementing STEAM education in Nepal. Journal of Education and Practice. 2018; 9(11).
19. Darling-Hammond L, Hyler M, Gardner M. Effective Teacher Professional Development. Learning Policy Institute; 2017. doi: 10.54300/122.311
20. Hynes MM, Conner J, McPherson R, et al. Industry-school partnerships: A strategy to integrate engineering education in K-12 schools. Journal of STEM Education: Innovations and Research. 2011; 12(3-4).