ENRICHING SCIENCE EDUCATION THROUGH STEAM APPROACH: A PARTICIPATORY ACTION RESEARCH

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AN ABSTRACT

of the dissertation of *Isha Basnet* for the degree of *Master of Philosophy in STEAM Education* presented on *18 January 2026*, entitled *Enriching Science Education through STEAM Approach: A Participatory Action Research.*

APPROVED BY

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Asst. Prof. Indra Mani Shrestha

Dissertation Supervisor

This dissertation explores the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education within science teaching practices. Utilizing a participatory action research (PAR) framework, the study investigates the effectiveness of incorporating STEAM principles to enhance student engagement, critical thinking, and interdisciplinary understanding. The research employs a collaborative approach involving educators, students, and stakeholders to co-create, implement, and evaluate STEAM-based science lessons. Through iterative cycles of planning, action, observation, and reflection, the study aims to develop innovative pedagogical strategies and curriculum designs that foster holistic learning experiences. The findings of this research contribute to the ongoing discourse on STEAM education and provide valuable insights into its application within science teaching contexts.

STEAM, as an educational paradigm, is broad, and there is immense value in expanding perspectives on the intersections of the arts and STEM that go beyond simple combinations. The core of STEAM is disciplinary learning that blurs boundaries, is creative and problem-oriented, and engages real-world complexity. Breaking the false dichotomy, STEAM offers students opportunities to engage in authentic problem-solving activities.

This study illustrates the importance of STEAM education in enhancing the skills necessary for educators, researchers, teachers, and students to develop a deeper understanding of scientific concepts. I have applied Participatory Action Research (PAR) as my methodology in the research process. Knowledge, constitutive interest, and transformative learning theory guided me as a PAR researcher. Different PAR cycles were followed to collect the information during the research.

The participants of this study are teachers at a private school in Lalitpur district. This study was based on the discussion, observation, interview and reflection that I collected from my own experiences as a participant researcher and the experiences of co-researchers, my students, along with my self-inquiry through my overall reflection. The data and information were collected from the field by the three Es (experiencing, enquiring, and examining) models of Mills (2011). This shows how a traditional science teacher undergoes a major shift from a conventional one to a transformative educator. The study ends with the worthy meaning of using the STEAM approach to teaching-learning practice recommending such approach in science classes of Nepali schools.

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शोध सार

स्टिम शिक्षामा दर्शनशास्त्रको स्नातकोत्तर उपाधिका लागि इसा बस्नेतको शोध प्रबन्धको शीर्षक 'STEAM दृष्टिकोणमार्फत विज्ञान शिक्षालाई समृद्ध बनाउने: सहभागीतामूलक कार्य अनुसन्धान' ४ माघ २०८२ मा प्रस्तुत गरिएको थियो ।

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उप.प्रा. ईन्द्र मणि श्रेष्ठ

शोध निर्देशक

यस अनुसन्धानले विज्ञान शिक्षण अभ्यासमा विज्ञान, प्रविधि, इन्जिनियरिङ, कला र गणित (STEAM) शिक्षाको समायोजनको बारेमा अध्ययन गरेको छ । यसमा सहभागीतामूलक कार्य अनुसन्धान (Participatory Action Research – PAR) को माध्यमबाट, सिकाइमा विद्यार्थीहरूको सहभागिता, समालोचनात्मक सोच र अन्तर विषयगत बुझाइको लागि स्टिम सिद्धान्तहरूको प्रयोग कत्तिको प्रभावकारी छ भन्ने कुराको अध्ययन गरिएको छ ।

STEAM मा आधारित पाठहरूको निर्माण, कार्यान्वयन र मूल्याङ्कनको लागि शिक्षक, विद्यार्थी तथा अन्य सरोकारवालाहरूले गरेका सहकार्यलाई नै यस अनुसन्धानको मुख्य विधिको रुपमा प्रयोग गरिएकोछ । योजनाकार्य, अवलोकन र प्रतिबिम्बका पुनरावृत्त चक्रहरू मार्फत, यस अध्ययनले समग्र सिकाइ अनुभवलाई प्रर्बधन गर्ने अनि नवप्रवर्तनशील शिक्षण रणनीतिहरू तथा पाठ्यक्रम विकास गर्ने लक्ष्य राखेको छ । यस अनुसन्धानबाट प्राप्त भएका उपलब्धिहरूले STEAM शिक्षासम्बन्धी चलिरहेको बहसमा योगदान पुर्याउनुका साथै विज्ञान शिक्षणको सन्दर्भमा यसको प्रयोगबारे महत्वपूर्ण अन्तर्दृष्टि प्रदान गर्दछ ।

STEAM आफैमा एक बृहत शैक्षिक अवधारणा हो, जसमा कला र STEM बीचको अन्तरसम्बन्ध गहिरो हुन्छ । उक्त सम्बन्ध नियाल्नको लागि शैक्षिक विषयहरूको सामान्य समायोजनलाई हेर्ने भन्दा निकै नै फराकिलो दृष्टिकोण आवश्यक पर्दछ ।

STEAM को चुरो भनेकै विषयहरूको सीमा मेटाउँदै जाने हो, जसले सिकाइमा सिर्जनात्मकता, समस्या समाधान प्रक्रिया र वास्तविक संसारको जटिलताहरूसँगको आत्मसाथलाई महत्व दिन्छ । STEAM ले एकल विषय शिक्षणको स्थानमा विद्यार्थीहरूलाई वास्तविक संसारका व्यवहारिक समस्या समाधानका क्रियाकलापहरूमा संलग्न गराउँछ ।

यस अध्ययनले STEAM शिक्षाको यस्तो महत्व चित्रित गर्दछ जसले शिक्षक, अनुसन्धानकर्ता तथा विद्यार्थीहरूलाई वैज्ञानिक अवधारणाहरू गहन रुपमा बुझ्न आवश्यक पर्ने सिपहरूको विकाश गर्न मदत गर्दछ ।

सहभागितामूलक कार्य अनुसन्धान विधि अपनाउने क्रममा, ज्ञान, संरचनात्मक चासो र रुपान्तरणमुखी सिकाइका सिद्धान्तहरूले पथप्रदर्शकले जस्तै काम गरेको छ । अनुसन्धानका क्रममा विभिन्न PAR चक्रहरू अनुशरण गरी जानकारी सङ्कलन गरियो । यस अध्ययनका सहभागीहरू ललितपुर स्थित एक संस्थागत विद्यालयका शिक्षक र विद्यार्थीहरू हुन् । अनुसन्धानका लागि छलफल, अवलोकन, अन्तर्वार्ता, प्रश्नावली तथा प्रतिबिम्वात्मक अभ्यासहरूको प्रयोग गरियो, जसमा म स्वयं एक सहभागी अनुसन्धानकर्ताका रूपमा मेरो अनुभव, सह–अनुसन्धानकर्ताहरूको अनुभव, र विद्यार्थीहरूको अनुभव समावेश गरिएको छ । साथै मेरो आत्मबोध र आत्म प्रतिबिम्वनले पनि यसमा स्थान पाएको छ ।

अनुसन्धानको क्रममा Mills (2011) को Three E (अनुभव गर्ने, जिज्ञासा गर्ने, र परीक्षण गर्ने) प्रारुपलाई प्रयोग गर्दै तथ्यांक तथा जानकारीहरू संकलन गरिएको हो । यसले एक परम्परागत विज्ञान शिक्षक कसरी क्रमशः रूपान्तरण हुँदै परिवर्तनकारी शिक्षक बन्छ भन्ने प्रक्रियालाई देखाउँछ । अन्ततः अध्ययनले शिक्षण–सिकाइ अभ्यासमा STEAM दृष्टिकोणको उपयोगको महत्वलाई उजागर गर्दै विद्यालयहरूमा विज्ञान कक्षामा STEAM दृष्टिकोण अपनाउन सिफारिस गर्दछ ।

.... ४ माघ २०८२

इसा बस्नेत

उपाधि उमेदवार

This dissertation entitled *Enriching Science Education through STEAM Approach: A Participatory Action Research* presented by *Isha Basnet* on *18 January 2026.*

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I understand that my dissertation will become a part of the permanent collection of the library of Kathmandu University. My signature below authorizes the release of my dissertation to any reader upon request for scholarly purposes.

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DECLARATION

I hereby declare that this dissertation is my original work, and it has not been submitted for candidature for any other degree at any other university.

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DEDICATION

I dedicate this dissertation to my beloved mother in law, Ms. Sushila Pandey whose unconditional love and sacrifices have shaped my overall journey.

Finally, I dedicate this work to all my family, my closest and dearest friends who supported me directly and indirectly and to all the readers of this dissertation.

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ABBREVIATIONS

ABL	Art- based Learning
BP	Blood Pressure
CDC	Curriculum Development Center
CSS	Cascading Style Sheets
DOE	Duke of Edinburgh
ERO	Education Review Office
HTML	Hypertext Markup Language
ICIMOD	International Center for Integrated Mountain Development
ICT	Information and Communication Technology
IT	Information Technology
K – 12	Kinder Garden to Grade 12
KU	Kathmandu University
KUSOED	Kathmandu University School of Education
KWL	Know, Want to know and Learned
LUPDA	Learn, Use, Practice, Design, and Apply
MPhil	Masters in Philosophy
PAR	Participatory Action Research
PBL	Project Based Learning
PD	Professional Development
STEAM	Science, Technology, Engineering, Arts, and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
VP	Vice Principal
ZPD	Zone of Proximal Development

LIST OF FIGURES

PRECEDING THE START

As a Science student, I completed my Master's research in microbiology on wound infections, which was purely quantitative. Truly speaking, I was completely unaware that the qualitative method also existed in the research field of science and technology. The MPhil study in STEAM education has fueled my curiosity in quantitative research and enabled me to explore how it is important for addressing complex societal challenges.

As a teacher, I was totally unaware of integrated teaching and learning, as I had no idea of the connections between context, concept, or discipline. In my perspective science was an isolated discipline and I never tried to see it through the lens of real-life connection. In fact, I was unaware of philosophical meaning of being a teacher. For me, teaching is to provide the information to the students from my memory and from the textbooks. Since the phase of being a student and entering the mode of being a teacher, I have always found that segregated teaching was the only option left, and I strongly believed there was no connection between subjects. Later, when I found myself permanently engaged in the teaching field, I began to listen and participate in various discourses of different approaches to modern teaching. Then I knew there was something like an integrated approach to teaching, something like STEM and STEAM. This research is another step toward understanding what remains unknown to me.

The name STEAM was very fascinating to me, as I was not familiar with it. When I joined the course, I was with new excitement and enthusiasm. I was also very skeptical about how I would manage with my studies, job, and two toddlers. If I reflect back, my journey was not easy, though. A science student without any background in education or qualitative research made me think twice about joining the course. Today, when I compare myself, I see a transformed teacher and educator, as the saying goes, "if you want to do better in life, compete with yourself." So, I see a better version of myself. The interactions with the professors during class, the insightful assignments, and peer discussion provided me with several ideas about education, teaching, and learning practices.

Holding a master's degree in science from a very reputable college and a reputable university left me blindfolded to my gaps as a teacher and educator. One indicator of teacher quality is pedagogical knowledge, which concerns creating effective teaching and learning environments for all (Guerriero, 2014). I used to believe that I was doing the best teaching practices, and also felt that teachers do not need to be updated. I can say I was overconfident, given the significant gap in pedagogical approaches. I decided to choose PAR as my research methodology. Also, I always wanted to conduct research among my own students and analyze and evaluate the results, for which PAR could be the best option. But collaborating with teachers and students and getting on the same page was not easy. This journey through my fieldwork and writing for the dissertation has completely changed my perception, as I have been able to explore, experience, and critically reflect on my own thoughts, beliefs, and actions.

I was guided by the traditional method
Impressed dark in the inner core of my brain
Digging down my memory lane
Rote learning all the formulas and names
It was all blank 1 year later
Did my rote all matter?
Jumping out was a very difficult task
Getting out of the traditional mask
Working together in a team
All that was possible because of STEAM

CHAPTER I
INTRODUCTION

This chapter deals with the introductory sections of the research. In the background section of the study, I've tried to present my personal experience as a science student and a science teacher. I have mainly explained my experiences of transformation from a traditional teacher to one who enjoys the STEAM approach to teaching and learning. Similarly, the problem statement, research purpose, and research questions are presented in the chapter. Likewise, this chapter concludes with the study's significance and its delimitations.

Background of the Study

Science education emphasizes rote memorization of callouts because scientific knowledge is poorly applied. Despite global interest in STEAM education, implementing it in the classroom is difficult in Nepal due to several constraints, including a lack of teacher education, limited resources, and assessment practices. To overcome this, PAR offers an empowering methodology to explore STEAM-based pedagogies to make science teaching more efficient and enhance students' engagement, creativity, and learning outcomes. Moreover, this also empowers science teachers, along with other subject teachers, to broader glocal educational knowledge.

Based on my own experience of being science student till university level and being a science teacher for thirteen years, I can say that the science classrooms in Nepali school are not inclusive and student friendly. Why not inclusive is, the science lessons are interesting and easy only for the academically bright students who can secure high marks or grades in exams but science lessons are boring and difficult for many students who struggle to achieve good marks. My experiences say that having memorizing capacity is the only key to get good marks in science lessons. The real learning is not a primary aim for the teachers and students in science classes. Although there are practical classes allocated in secondary level lessons, those practical classes also are dominated by memorizing the steps and writing them in the practical exercise books.

My Science Learning in the Traditional Education System

When I was a high school student, I had to rote call all the definitions, formulas, and procedures in science. The teacher-centric, lecture-based approach did not provide space for activity-based learning, field trips, or the integration of subjects. As far as I remember, I used to note down the dictated paragraphs and definitions, which I later had to recall by rote, very loudly, making it difficult the next day when speaking. Despite having such difficulty in memorizing the facts, I did not understand what I had memorized. No matter what I learnt and how I learnt or even if I did not learn anything, I was a good student because I could memorize the facts and could write them well in the exams. The perspective of the teachers, students and parents was that science was the subject demanding hard work and requiring memorization.

In a traditional classroom, the science teacher usually solves problems from textbooks, and students are asked to copy the solutions provided by the teacher (Shrestha, 2011). Now, I realize what I tried to learn was never based on understanding the concepts; rather, I was more exam-centric, aiming to achieve better marks. Because of the process, I barely remember anything I learned in high school. Moreover, based on the good marks I achieved in high school, I chose Science as my major subject, not because of my interest or ability to learn science, which led me to struggle a lot in my higher studies. Nowadays, both students and teachers seem to be aware of the consequences of selecting subjects without interest or ability. Students are more wisely choosing their major subjects and studying deeper perspectives across all aspects than in the past.

First of all, I had a dream of studying medicine, but I could not fulfill it because I did not have a high enough competitive score or sufficient financial resources. Thus, I had to continue my education with pure science subjects in bachelor's and master's level.

After completing my master’s degree in science in 2011, I had a few options for building a career based on my education. I chose to be a chemist and worked in a pharmaceutical company for a year. The job neither provided me with enough payment nor satisfaction. The working hours were too long compared to the benefits I received. The next option for me was to become a science teacher. Career choice is one of the biggest dilemmas and challenges in any student’s life, which involves the interplay of many factors that are intricately intertwined (Kazi & Akhlaq, 2017)

I as a Traditional Science Teacher

2013 AD was the year I became a teacher. Primarily, to become a teacher was to get a job at that time. I had not received any formal education or training in teaching. Yet, I was confident that I could be a teacher because I had witnessed my own teachers teach me from primary school through university. To be honest, I tried to replicate the teaching style of my own teachers in the classes. I did the same as I had seen my teachers doing in the classroom. What I knew about teaching was to pass along the information from the textbook to the group of students, have them read the definitions, and have them write the answers to the textbook's questions. The high achievers would get rewarded, and the struggling ones would be disappointed or punished. I was guided by the idea that learning means memorizing facts. Learning is a measurable change in behavior (Dierking, 1991). Now, I think I was oriented towards the behaviorist approach of teaching.

The tendency to adopt traditional methods was not merely a matter of personal choice but was deeply shaped by the education system of Nepal. The general structure of schooling emphasizes content coverage, summative assessment, and complete rely on textbooks. The academic and nonacademic society has not only been accepting but also practicing such kind of structures of school in Nepal. The classroom practices in Nepali context based on recent studies confirms that classroom practices are largely driven by assessment of learning rather than assessment for learning where the primary focus is on grading and ranking students rather than fostering creativity and critical thinking (Acharya, 2025). Teachers are often expected to complete the syllabus within limited timeframes where implementation of innovative pedagogies is almost impossible. As a result, I found myself relying on lecture- based instruction, rote learning, and teacher- centered approaches. The main reason for doing so is the demand of the assessment system for better grades. Traditional summative approaches continue to dominate, often emphasizing memorization while neglecting students' creativity, participation, and higher- order thinking skills (Shrestha, 2025).

Furthermore, my job as a teacher were guided by various factors embedded within the educational system. Curriculum guidelines, assessment practices, and administrative expectations developed the limitations that directed my teaching practices. The dominance of summative assessments encouraged a focus on factual knowledge rather than conceptual understanding. My actions were not entirely autonomous rather influenced by institutional discourses, expectation of what good teaching is like, and need to maintain classroom control and efficiency. In Nepal, teaching practices indicate that the pedagogical approaches are guided by institutional expectations, limited professional support, and a culture where teaching is perceived as ritualistic rather than reflective and transformative (Bhandari et al., 2025). This helped me to recognize my actions and allowed me to critically reflect on my practices and gradually reconstruct my pedagogical approach toward more student-centered, inquiry- based learning.

It was 2014 when I got my first teaching training. I felt teaching could be easier, and learning could be better than what I was doing in the past, both as a teacher and as a student. Yet, I continued in a similar way to a traditional, teacher-centric teaching method. Gradually, I got opportunities to attend more trainings and professional development sessions, and I began to start learning about the modern and progressive way of teaching. Slowly, I also began to practice them as much as I could. Professional development training helps teachers to learn and implement new ideas in their practice (Kennedy, 2016). But the textbook-centric examination pattern, parents' expectations, school management's instructions, and even my own ability were major obstacles to facilitating proper learning in the classes. Yet I tried my best to provide a real science-learning environment based on my knowledge and experience.

My Science Teaching and STEAM Education

Despite having 13 years of teaching experience, I had no formal academic coursework in education. I had a strong desire to improve my teaching style and to gain knowledge of modern, progressive educational pedagogy. But I did not have a clear vision of how to convert my teaching pattern into a meaningful way. I wanted to become a professional teacher in a real sense. It means I realized some improvisation in teaching style was required for me to become a better teacher although I was a teacher by default. At least, I wanted to know how science teaching or learning could be easy and interesting. I began reflecting on and critiquing my own metaphors of learning, which led me to realize that receiving and teaching are merely informative practices (Shrestha, 2011).

Finally, I learned about something called STEAM from my colleague at the school where I was working in 2020. I realized that it could be an academic course that would value and recognize all the experience and knowledge I gained as a teacher over 7 years. Then I decided to join Kathmandu University and learn what STEAM education is. This may relate to Dewey's (1938) claim that teachers must acquire new knowledge and put it into practice to promote better learning in the classroom.

Science, one of the subjects that high school students learn, can be taught using different pedagogical approaches. STEAM pedagogy is among the most discussed pedagogies today. STEAM teaching and learning approaches aim to develop students' transdisciplinary abilities so they can engage effectively as decision-makers in debates on sustainable development (Taylor & Taylor, 2019). This research examines a few aspects of science teaching using STEAM pedagogy. As I have been involved in science teaching for nearly a decade and have been a student of science for years, I have found science teaching and learning to be very complicated issues in my context. As a student, I found science a very difficult subject to learn. Likewise, as a teacher, I experienced several difficulties in engaging students in meaningful science learning. Recently, I came across an approach called STEAM, which claims that science learning and teaching are not difficult; rather, they can be as easy and interesting as other subjects for both students and teachers. The only thing is that we need to be aware and skilled enough to handle teaching-learning activities properly. Clandinin and Connelly (2000) argued that teachers' professional and personal experiences are not biased but valuable sources of knowledge, as teaching is shaped by context, time, and relationships. When a teacher becomes a researcher, they can generate a deeper understanding of educational practice and change.

STEAM, a modern teaching approach, integrates science, technology, engineering, the arts, and math. The STEAM approach is well known for getting students involved in inquiry, discussion, and problem-solving activities. It is the most required method that helps students to engage in meaningful learning activities, work through the creative process, etc. STEAM develops an educational model that can transform the traditional academic subjects into an integrated curriculum (Yakman, 2008). To prepare a technological force for the 21st century, it is crucial to train a diverse STEM-literate workforce (Merchant & Khanbilvardi, 2011). Despite the above statement, many students in my teaching career are disoriented from STEM subjects like mathematics and science in their school days. One reason to disorient them is that they do not see the connection between those subjects in real life. Teachers incorporate real-world connections into lessons to motivate learners or help them master a concept, rather than to develop learners' ability to apply mathematics to real-life problems (Gainsburg, 2008). Students cannot see the application of the mathematical formula in reality, nor can they understand the scientific theory from a practical perspective. The subjects of STEM education are considered the most difficult at the school level because the students are unable to internalize the concepts of science and mathematics. The teachers are unable to integrate their lessons into day-to-day reality. It’s important to link science to everyday life (Andree, 2005).

Art is a powerful learning tool for students to increase motivation, aligning with their interests and abilities, as it offers diverse opportunities for communication and expression (Izadi, 2017). The students remain motivated as they can get opportunities to explore and learn based on their interests and strengths, not just through words but also through visuals, music, movement, and other creative forms. The emergence of a creative economy makes it important for students to develop entrepreneurial skills as companies increasingly rely on creative professionals to trigger business innovation (Roege & Kim, 2013). The entrepreneurial skills include creativity, critical thinking, and collaboration, which help create opportunities for themselves and others. For a well-rounded, comprehensive, engaging education that supports success and thriving, the liberal arts can be the right choice. Although adapting liberal arts to science education is not a simple task, reformers are eager to explore in practice to move beyond generalizations (Becker, 2014). Modern liberal arts and science education is a system designed to foster the desire to learn, to think critically, to communicate proficiently, and to prepare them to function as engaged citizens.

What I believe is that high school students could have learnt science and mathematics more effectively if they had found them at every step of their daily activities. The teachers’ job would have been much easier and more effective if they taught science and mathematics not only in the classroom or in the laboratory but also outside the classroom. I usually question myself why a science teacher does not ask the student to experience science with water, sun, wind, and the rain, why not the teacher guides the students to explore science in cooking at home, why not a student is asked to inspect his/her bicycle or any other machines and find the theory of science and mathematics applied there.

Thus, we tried to identify some learning and teaching techniques based on pure practical approaches. Usually, the conventional understanding holds that practical work in science is laboratory experimentation. But in our research, a practical approach tends to involve exploration, experience, and reflection beyond the boundaries of the traditionally designed classroom and laboratory. I strongly believe there's a real need to explore ways to connect STEAM education with day-to-day life. Traditional science education is very different from students' everyday reality because it seems distant from the ordinary world (Kervinen et al., 2020). Students might have the misconception that science is a subject of only facts and theories, and that it is meant to be learned through rote recall and memorization rather than linked to real–life situations. Such a wrong concept leads students to lose interest in the subject. Also, research has repeatedly shown that a major reason for the difficulties of affiliating with science and science learning is that students do not perceive science as connected to their everyday lives, experiences, and cultural resources (Archer et al., 2010). So, the major gap between classroom teaching of science and everyday life can be bridged.

Problem Statement

One of the various reasons for students to find science boring and without interest is that it has not been integrated with other subjects, and it has not been practically connected with the real world. STEAM education highly encourages for interdisciplinary approach in education. If students find science connected to their real lives or if they learn science that integrates with other subjects, the learning can be not only real but also interesting for both teachers and students. Connecting science education with everyday life is about enculturing students into various ways of thinking, acting, knowing, doing, and so on (Andree, 2005).

The interdisciplinary approach brings together two or more perspectives, with interactions and effects on each other's perspectives, which is considered the most effective method of teaching and learning (Pun, 2015). In the context of science teaching in Nepal, I have found a very rare practice of integrating art and an interdisciplinary approach in teaching and learning activities.

Most schools use textbooks to teach different subjects. So is the case in science as well, and those textbooks are not very closely connected to art-based activities, nor do they ask students to integrate science with other subjects. At the high school level, neither art-based pedagogy nor an interdisciplinary approach is taken seriously. The students are expected to grasp the content by mastering it and ignoring the life skills (Manandhar et al., 2022). The situation of the school where I am working is also not very different from the general practice in other schools in Nepal. Nevertheless, we have started integrating different subjects into activities such as educational excursions and science fairs. Especially in our practice, when students are taken on a science educational excursion, language arts, social studies, and environmental education are integrated. We consider this a bit of practice in interdisciplinary pedagogy, though it's not enough. Lhomi (2020) mentioned that "the contextual and integrated approach can scaffold learners to consolidate their knowledge, skills, and attitude" (p. 3).

Teaching science in an interdisciplinary approach to have a better understanding and to be able to solve the real-world issues interconnecting science, technology, engineering, and mathematics. "The notion of STEAM (Science, Technology, Engineering, Arts and Mathematics) is an emerging discipline unique in its desire to provide a well-rounded approach to education" (Rolling, 2016, p. 2). Thus, it supports holistic learning, which aims to develop academic knowledge along with creativity, problem-solving, and critical thinking skills.

In addition to the practical problems students and teachers face in the classroom, the policies governing teaching are equally important to discuss. As school-level education now falls under the jurisdiction of the municipal government, which represents the revolutionary transformation, the local government should simultaneously address multiple existing problems (Neupane, 2020). However, due to a shortage of experts and local leaders who are not sufficiently experienced to handle challenges effectively, the implementation of such initiatives remains limited. Thus, to transform the entire education system, a stepwise process, as in assessment, policy-making, and the proper implementation of the policy, is essential to ensure meaningful and sustainable transformation across the education system. More important is collaboration with teachers, communities, experts, and higher levels of governance to ensure coherence and shared responsibility.

In teaching and learning science in the context of Nepal, there are posing challenges in the effectiveness and quality of education as unsatisfactory achievement, poor absorptive capacity of students in higher education, and their inability to achieve success in external competencies (Sharma, 2010). Consequently, students become passive recipients of information, limiting their engagement, curiosity, and readiness to succeed in advanced studies and real-world scientific knowledge.

Paudel (2020) reported that instruction in science classrooms is often dominated by lecture and has a poor track record of implementing child-centered, inquiry-based instruction, citing findings from the Education Review Office (ERO)

(2015). Science education in Nepal faces systematic and structural challenges that significantly hinder its growth and effectiveness. The lack of a strong institutional framework dedicated to promoting science education poses a significant challenge to the systematic development of Science education.

Science education in Nepal is characterized by inadequate institutional support for its promotion, the absence of national science competency standards, few science and technology research centers, limited funding for science and technology research, a lack of professional science teachers and researchers, etc. (Paudel & Rajbhandary, 2022). Science education needs significant improvement, emphasizing sustainable national development. Moreover, proper implementation of improved education policies is essential to improve the desired goal of education, allocating dedicated funds for infrastructure development and improving the quality of teachers. Insufficient funding for science and technology further constrains the development of well-equipped laboratories, scientific research, and collaboration. Additionally, the shortage of professionally trained teachers weakens the overall system of education, restricting the formation of a research-oriented scientific community.

The enrollment of students in higher education in science is very low, i.e., only about 7.11% compared to other departments, particularly the minority of female students in engineering (University Grant Commission [UGC], 2020). This scenario can be traced back to experience at the school level, as during this time, students begin to develop attitudes and interests in science. The traditional method of science teaching in schools fails to engage students meaningfully, leading to low enrollment of students in higher education. Over the past decades, Nepal has made notable progress towards gender parity, especially at the primary and lower secondary levels, due to several government policies. However, challenges still remain at the secondary and higher secondary levels, particularly in rural and marginalized areas, where socio-economic factors play a vital role. Several other factors contribute to this trend, including limited access to quality science education at the school level, lack of role models, and mentorship. Thus, gender responsive educational practices and a supportive learning environment are required to strengthen participation in higher education in science.

Improvements in science accelerate the nation's social and economic development, which can be achieved through carefully planned science education that meets the needs of the population. Effective science education enhances several skills required for the 21st century. It also prepares workforce capable national challenges and support sustainable development.

The curriculum in Nepal is focused on recall of factual knowledge that promotes rote learning, CDC focused on assessment finding as a reference through NASA while reviewing the primary level curriculum more supportive, promoting activity-based learning and fostering higher cognitive skills with interdisciplinary integration of the curriculum (Poudel & Bhattarai, 2018). The revised orientation emphasizes activity-based learning, encourages inquiry and exploration and fosters higher cognitive skills through interdisciplinary integration of subjects. By connecting concepts across the discipline and engaging students in hands-on experiences, the curriculum aims to promote deeper understanding, making a shift towards more progressive and holistic science education practices in Nepal.

When I critically reflected on our own classroom practices and gathered students' experiences in my school, I planned to engage in this Participatory Action Research. Through classroom interactions, informal discussions with students and colleagues, I observed that science teaching was largely content-driven and exam-oriented. Even though students could recall scientific facts, they often struggled to apply concepts in real–life situations. Moreover, teachers also expressed challenges in integrating concepts due to several constraints. Based on the above-mentioned needs, the STEAM approach emerged as a promising approach to address the observed challenges.

Research Purpose

The main purpose of the research was to explore how the STEAM approach can enrich science education by promoting meaningful learning, creativity, and student active engagement in the science classroom.

Research Questions

Research questions guide the research in a particular path to achieve the specific objectives. My entire research process attempted to answer the following two main research questions.

1. How does STEAM pedagogy engage students in meaningful science learning?

Sub-questions:

a. What learning experiences do students perceive during STEAM-based science activities?

b. What challenges do teachers face while implementing STEAM pedagogy in the science classroom?

2. How does STEAM pedagogy integrate art and creativity in the science classroom?

Sub-questions:

a. How do student's express creativity through art-integrated projects and activities?
b. What are the challenges teachers face while integrating art and creativity in science through the STEAM approach?

Significance of the Study

STEAM education strengthens the foundation of STEM subjects and prepares learners for the 21st century with all the required skills. Moreover, scientific knowledge and skills help to satisfy basic needs of humans and give a quality life, learning science through STEAM pedagogy has become very crucial. Science is believed to carry complex and abstract concepts because of its high level of cognitive demand. Thus, it's very important to make this subject really easy to learn and teach using various pedagogies where students are enjoying the process of learning. Traditional methods of teaching are still struggling to make the learning process interesting and easy for the students. In this context, it's very significant to find out new methods of teaching science. STEAM pedagogy or STEAM approach can be one of the easy and effective ways to deal science.

Giving argument and talking about the theoretical aspects of STEAM pedagogy is very common and sometime it sounds easy also but, this practice is not very common and even the output or effectiveness of STEAM pedagogy is yet to be observed or found out. This is also one of the reasons we think our research has academic meaning and significance.

Delimitation of the Study

Every research study has a vast and profound scope to explore, offering enormous possibilities for uncovering unlimited findings. One of the delimitations is the challenge of implementing various art-based pedagogies in science teaching throughout the academic session. It was really difficult to find out the output or usefulness of art-based activities in science classes. Similarly, interdisciplinary approaches in high school practice require a lot a homework and trainings, resources which might have been a bit demotivating for the teachers.

Chapter Summary

This chapter highlighted the importance of STEAM education in enriching science teaching and learning. The chapter discusses how traditional science instruction often emphasizes science teaching and learning. The chapter discusses how traditional science instruction often emphasizes rote learning and examination-oriented practices, which limit students' engagement and creativity.

In response to this, STEAM pedagogy is introduced as an integrative learner-centered approach that promotes meaningful learning and real- life application of scientific concepts. Moreover, this chapter is also about the research design and approach providing an overview of the participatory action research framework adopted in the study. Finally, the scope, significance, and limitations of the research are presented establishing a strong foundation for remaining chapters.

CHAPTER II
LITERATURE REVIEW

In this chapter, I have tried to show various approaches of teaching science mainly through interdisciplinary approaches with the help of supporting literatures. Here I have included thematic review, theoretical review and empirical review of the paper. Further I have connected my research with some theories as critical thinking skills and constructivist approach. Several previous researches related to this topic has given me a new perspective of teaching science and connecting it to several other disciplines.

Thematic Review

I have reviewed the thematic literature of STEAM Education in this section. In order to make it systematic and clear, I have divided the section into two sub headings.

STEAM Education: What, How and Why?

The primary theme of the research is STEAM Pedagogy and science. Thus, the entire research tries to go deep into the theme how STEAM supports or affects science teaching or learning.

Students are likely to learn the reality and facts within themselves and around themselves from the subject called science. Science is one of the branches of academic discipline which provides the information of facts and reality. Thus, science is actually present in each and every aspect of learning in life. Science deals with the nature of every object that exists in the word.

STEAM education engages students in transformative learning that promotes interconnected ways of knowing such as cultural self- knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action (Taylor, 2015). So, it enhances all the skills that are required for 21st century through authentic and meaningful learning.

One of the problems of school education in Nepal is the overemphasis on the content that is presented in a more segregated manner in each subject (Pant et al., 2020). Teachers of different subjects as Science, Mathematics, English, etc. are taken as isolated wings without any connection. Thus, it reflects the traditional subject –

centric approach of teaching and learning rather than connecting to our real life and approaching through multiple perspectives.

Educators of Nepal have many times emphasized about the disintegrated, disengaged and disempowering practices of education in context to Nepal and even after implementing the concept of integrated curriculum in primary grades, there has been a chaotic scenario due to lack of trainings among the educators and the stakeholders (Luitel, 2019). Despite applying the integrated techniques, the disciplinary egocentrism among the stakeholders of education has been found as a major difficulty and integrated themes are taught as disciplinary approaches (Shrestha et al., 2022).

"Science is a body of knowledge about the natural world (the environment) that is testable, verifiable or falsifiable by using organized scientific methods and skills" as stated by Sylvester et al. (2019). This statement supports the students/teachers to understand the realistic sense of science teaching or learning. Students develop skills as observation, measurement, classification, communication, experimentation. It means students get to know what things are there in the world, why they exist and how they function through science. Scientists have developed the scientific theories and fact through in-depth research, experiments, observation, tests, evaluation. In fact, science is not something beyond reality, rather it's the thing that we face each and every time.

As science teaching and learning have become a complex subject, the research aims to find an easy and effective way to teach and learn this subject. STEAM pedagogy is a widely discussed and rapidly experimented with approach to teaching technical subjects like science, mathematics, technology, and engineering through the lens of art. The core theme of STEAM is to integrate art-based activities to make the teaching and learning process easier for subjects in science and technology. This research focuses on science teaching using STEAM pedagogy.

Taylor and Taylor (2018) stated in an article that STEAM teaching and learning approaches aim to develop students' transdisciplinary abilities to engage as future citizens. One of the reasons for science to be very difficult and dry subject is it is understood as standalone subject and is not connected with disciplines. STEAM allows or prescribes science teaching to connect with other subjects. Thus, a transdisciplinary approach is one of the strengths of the STEAM approach.

Supporting STEAM pedagogy, Sylvester et al. (2019) cited that “science is concerned with finding out about our environment and how the various components relate with one another”. The recipients can meaningfully interact with the environment. This helps students develop an interest in subject matter, connect with the environment, and engage in meaningful learning by directing their natural curiosity. STEAM pedagogy can be the best approach for authentic, meaningful, and inquiry-based learning in Science. As science education can be far from students' real lives, it’s often misunderstood that science only deals with the facts and that it needs to be learnt through rote recall. Also, research indicates that the disintegration of science from real life is a cause of students finding this subject uninteresting (Archer et al., 2010). So, through the various methodologies for making learning fun, drama, music, designing, painting, trips, etc., can be integrated into science.

Since this research is about enriching science education through STEAM, the entire research revolves around what STEAM is, why it is required in science education, and how STEAM supports or affects science teaching and learning. With technological advancements and globalization, educational planners around the world endeavor to educate the next generation to become technology-literate and take an interest in subjects such as Science, Technology, Engineering, and Mathematics in the face of increased economic competition (Khine & Areepattamannil, 2019). STEAM education is an integrated, interdisciplinary approach to teaching and learning where students apply knowledge and skills from multiple subjects to solve real-world problems. Unlike traditional subject–based teaching, STEAM emphasizes creativity, critical thinking, collaboration, and innovation by connecting scientific concepts with artistic expressions and design thinking.

Science education through STEAM helps increase learners' motivation at each level of education and enhances their interest in the disciplines of STEAM. STEAM has helped increase student interest, achievement, and motivation through STEAM classes, particularly in subjects that involve real-world problems, which leads students to choose careers in STEAM fields (Boytchev & Boytcheva, 2020). STEAM has also helped students in the cognitive domain, such as memory, reaction time, and innate intelligence, as well as in the psychomotor domain, including physical measures, coordination, and skill. Various researchers have provided sufficient evidence of the lack of student attention in the digital era, which undermines student engagement in digital education.

Well-recognized as a powerful driver of national economic growth, STEM lies at the heart of worldwide calls for educational reform, urging the production of graduates with creative and innovative abilities and an increasingly high-tech workforce (Taylor, 2016). STEAM education has become a worldwide focus of innovation and creativity through initiatives as the 21st century minds, which prepare children with 21st century skills for the jobs of the future, including the ability to think smart and creatively, solve problems, persist, take risks, have digital skills, and collaborate effectively. STEAM education is a curriculum philosophy that empowers science educators or teachers to engage in school-based curriculum development. Learning activities that integrate STEAM disciplines effectively engage minority and disadvantaged students, thereby improving literacy and numeracy competencies.

STEM educators have a moral imperative to develop curricula that prepare students with transdisciplinary abilities to participate as socially responsible citizens in resolving global crises such as climate change and plastic pollution (Taylor & Taylor, 2019). By adopting transdisciplinary STEM or STEAM curricula, educators can empower students to critically analyze real–world problems, understand socio-environmental impacts, and design sustainable solutions. Such curricula foster thinking, environmental literacy, and ethical reasoning, encouraging learners to recognize the interconnectedness of various systems. Moreover, embedding real-world issues into classroom learning helps students develop agency and global citizenship, motivating them to take informed action.

Students are provided with ill-defined tasks, multiple ways to approach a problem, and opportunities to cross several disciplines in authentic learning, where the task is set in a real-world context. STEM and STEAM education scholars agree that STEAM initiatives enable students to transfer their knowledge across disciplines, helping them creatively solve problems and view problems through multiple angles or perspectives that can be applied to real-world contexts (Bertrand & Namukasa, 2020).

STEAM-based teaching has a significant impact on participants' affective factors, including attitude, self-confidence, engagement, interest, motivation, satisfaction, self-regulation skills, and teamwork. There is substantial evidence that STEAM practice provides a comprehensive understanding of how affective factors such as attitude, interest, and motivation influence participants in STEAM instruction (Wu et al., 2022). Through collaborative tasks, experiential learning, and technology-enhanced inquiry, STEAM instruction fosters meaningful engagement and mitigates the negative effects of digital distraction, leading to more balanced and learner-centered educational experiences.

By adopting transdisciplinary STEM or STEAM curricula, educators can empower students to critically analyze real-world problems, understand their socio-environmental impacts, and design sustainable, context-sensitive solutions. Such curricula foster systems thinking, environmental literacy, ethical reasoning, and civic responsibility, encouraging learners to recognize the interconnectedness of ecological, social, economic, and technological systems. Moreover, embedding real-world issues within classroom learning enhances students' sense of purpose, agency, and global citizenship, motivating them to take informed action beyond the school environment.

STEAM Pedagogy and Assessment

Appropriate assessment practices are crucial for effective learning. In formal school education, various systems are developed to assess students' learning. STEAM pedagogy not only helps students learn effectively but also assesses their learning effectively. In STEAM pedagogy, students are assessed through various activities from the very beginning of the project, designed to support active, engaged learning.

STEAM pedagogy and assessment are interconnected. STEAM pedagogy emphasizes learner-centered, inquiry-driven, and real-world problem-solving approaches, which require an assessment method that goes beyond traditional tests to evaluate both the learning process and outcomes. Hence, formative, performance-based, and authentic assessments are commonly used to provide ongoing feedback and support the development of conceptual understanding, skills, and creativity, as well as collaboration.

STEAM places learners at the center, where students actively construct knowledge by investigating meaningful questions and solving real–world problems. The instructional method for STEAM pedagogy is mainly project-based, problem-based, and inquiry-based learning, all of which are learner-centered and based on the same principle (Milara & Orduña, 2024).

The impact of STEAM teaching and learning can be evaluated through learning performance, affective cognition, and higher-order thinking. The STEAM instructional approach-based teaching is effective at all levels of education, as it emphasizes collaborative projects that can lead to transformative learning experiences, resulting in improved student attainment and academic performance (Amanova et al., 2025). Moreover, STEAM pedagogy empowers teachers to adopt reflective practices and continuous pedagogical improvement, aligning classroom instructions with real-world demand and future workforce skills.

With technological advancements and globalization, educational planners around the world endeavor to educate the next generation to become technology-literate and take an interest in subjects such as Science, Technology, Engineering, and Mathematics in the face of increased economic competition (Khine & Areepattamannil, 2019). STEAM education is an integrated, interdisciplinary approach to teaching and learning where students apply knowledge and skills from multiple subjects to solve real-world problems. Unlike traditional subject–based teaching, STEAM emphasizes creativity, critical thinking, collaboration, and innovation by connecting scientific concepts with artistic expressions and design thinking.

STEAM is implemented through student-centered, inquiry-based, project-based learning strategies, gamification, VR technology, robotics, the flipped classroom, problem-based learning, experiential learning, and collaborative learning. More teaching strategies, such as inquiry-based learning, hands-on activities, design-based learning, action research, and outdoor learning, are included. Through collaborative tasks, experiential learning and technology enhanced inquiry, STEAM instruction fosters meaningful engagement and mitigates the negative effects of digital distraction leading to more balanced and learner centered educational experiences.

Despite the increasing interest in STEAM education, research on the effectiveness of instructional approaches and ways to assess has been lacking. Moreover, the skill dimension needs to be identified to provide appropriate problem-solving opportunities within instruction. In K-12 schools, assessing students' collaboration is needed to identify the dimensions of the skill and provide appropriate problem-solving opportunities within instruction, as STEAM education has been gaining popularity (Herro et al., 2017). One of the very important skills that must be assessed is collaboration, as it is typically embedded in problem-solving.

In the transdisciplinary approach of STEAM, instructors adopt holistic approaches that blur the boundaries between individual disciplines, where, despite teaching concepts, real-world issues or problems serve as meaningful entry points for learning. Instructors use transdisciplinary ideas in holistic approaches, and ideas and problems are presented in the context of students' lives or the local community, where students are allowed to solve the problem collaboratively by exploring and designing solutions (Quigley & Herro, 2016).

Although each discipline of STEAM has its own distinct nature, goals, and methods of inquiry, STEAM emphasizes the purposeful integration of knowledge and skills across disciplines to address complex, real-world problems. Instead of just treating subjects as a separate silo, STEAM encourages learners to draw connections among each discipline of STEAM, enabling them to view the problem from multiple perspectives. While the nature and objectives of each subject differ, STEAM education encourages integrating knowledge and skills from multiple disciplines to tackle complex issues (Wu et al., 2022).

Wahono et al. (2021) investigated the impact of integrating socio-scientific issue–based instruction with the STEM-6E instructional model—engage, explore, explain, engineer, enrich, and evaluate—supported by a multi-level assessment framework. Their study examined how this integrated approach influenced students' academic performance, learning motivation, and conceptual understanding in science. The findings revealed that integrating socio-scientific issues within the STEM-6E framework significantly enhanced classroom interactions by actively involving students in meaningful, real-world problem solving and critical discussions. As a result, students demonstrated notable improvements in scientific performance, increased motivation to learn, and a deeper understanding of scientific concepts. The study highlights the potential of STEM-oriented, socio-scientific pedagogy to create engaging and learner-centered science classrooms.

Formative assessment plays a crucial role in evaluating multimedia projects, which are commonly produced in STEAM learning environments. Such projects require ongoing feedback and reflection to support students' learning processes rather than focusing only on final products. Hence, formative assessment practices are highly applicable to effective technology integration within STEAM instruction. Despite teachers' confidence in using technology, its potential is not fully utilized for formative assessment and is seldom employed to support collaborative learning. As reported by Herro et al. (2018), many teachers use technology minimally to monitor student progress and facilitate collaboration, highlighting a significant gap between technological capability and pedagogical application in STEAM education.

LUPDA assessment, which aligns well with STEAM pedagogy, is an approach that focuses on meaningful, real-world, performance-based tasks that support students' learning with continuous feedback. This comprehensive rubric-based assessment was performed to evaluate K-12 students' transdisciplinary learning. The research model consists of five dimensions- learn, use, practice, design, and apply that correspond to the five disciplines of STEAM education. The indicators proposed in this model are rooted in transdisciplinary theoretical foundations and have been validated through their applications in STEAM learning activities, enabling teachers to effectively assess students' learning outcomes in transdisciplinary STEAM education (Cheng & Huang, 2025).

Theoretical Review

Some academic or educational theories related to teaching pedagogy are highly relevant to this research. A review of theories supporting the traditional approach to teaching science provides evidence that science learning has become difficult and monotonous. At the same time, the theories that advocate the STEAM pedagogy are to present the logic why integrated pedagogy or STEAM pedagogy are beneficial for the education system. The following is an analysis of a few relevant theories in this particular research.

Critical Thinking in STEAM Education

I reviewed critical thinking skills in which the STEAM pedagogy is used in science learning. "Critical thinking is reasonable and reflective thinking that is focused on deciding what to believe and what not to believe" (Ennis, 1985, p. 45). It is considered a major problem-solving skill, involving analysis, evaluation, and reasoning about a particular subject matter. Research shows that people develop critical thinking skills at a very young age, and educators can enhance these skills by using real–world problem contexts, providing open-ended tasks, etc.

Halim and Mokhtar (2015) mentioned that "Scientific knowledge is developed and constructed by scientists through inquiry, including employing critical thinking skills with the aim to verify the information as true, valid, and reliable". The critical thinking process affects learning in science, and teachers play an important role in ensuring it is integrated into their teaching.

Educators are well aware of the importance of critical thinking skills, which are among the major objectives of students' learning. Habermas's idea of the interest in knowledge advocates for the space of critical thinking in education (Grundy, 1987). Similarly, Mezirow's transformative learning theory is closely connected to Habermas' critical theory (Fleming, 2018). Mezirow's theory of transformative learning, attending to its reliance on critical theory, which contributes to the development of critical reflection and emancipatory learning.

Recently, critical thinking has been considered one of the skills needed for 21st century citizens. Usually, subjects in the social sciences, such as philosophy, psychology, education, and sociology, require strong critical thinking skills. But due to a lack of clarity, science seems to be disintegrated from critical thinking.

Critical thinking can be used to improve the science classroom through scientific creativity (Demir, 2015). Critical thinking skills make the classroom effective as it allows multiple perspectives and alternative and appropriate techniques to learn.

In Beford's (2010) proposal, conventional science topics such as global warming can be learnt through critical thinking, and students can identify the reality and misconceptions about the topic. He named this method 'agnotology,' an active learning strategy that engages students with class material rather than having them passively listen to lectures.

Critical thinking and scientific reasoning sound similar. Yet, they are distinct constructs that include various higher-order cognitive processes, metacognitive strategies, and dispositions involved in making meaning of information (Dowd et al., 2018). Critical thinking helps form opinions, think critically, solve issues, and sort through information to identify what is irrelevant. Scientific theories involve reasoning and problem-solving skills in generating, testing, and revising hypotheses or theories.

STEAM is an integrated and interdisciplinary academic approach. It encourages students to think more broadly and critically about real-world problems (Pant et al., 2020). This approach helps solve real-world problems by integrating all streams in a creative way.

Kivunja (2015) says, "Critical thinking is a cognitive process that creates the ability to interpret, analyze, and evaluate information, arguments, or experiences with a set of reflective attitudes, skills, and abilities to guide our thoughts, beliefs, and actions" (p. 431). So, this definition gives us a thought of how critical thinking is a very important skill that helps us to understand facts, concepts, and theories in depth, with all their justification. These skills also help to solve major issues and problems, are rational, and are considered a key component of daily life.

During our practical skills, we face major difficulties, one of which is emotion, as we rely on it to guide our actions. An appropriate emotion at the right place in thinking is essential, but the same emotion can be destructive if it's in the wrong place, and the six hats method allows us to use emotions and feelings at the right place (De Bono, 1992, p. 8).

"The six thinking hats metaphor represents six different cognitive approaches to critical thinking and analysis to understand an issue or problem and trying to come up with an appropriate resolution" (Kivunja, 2015, p. 4). In the metaphor, the six hats are colored Black, Blue, Green, Red, White, and Yellow. Each hat represents a different logical and philosophical approach to critical thinking about a problem and trying to solve it.

Constructivism

For our research, I have included constructivist theory. Constructivism, an important approach in education, promotes meaning-centered, inquiry-driven, and authentic learning by helping construct knowledge through observation, discussion, experience, and interaction. Also, it helps to build or incorporate new knowledge based on prior knowledge or experiences. It also posits that knowledge is not transferable. Since learning happens through common interaction with someone. Thus, it's a social act but not an abstract concept (Dewey, 1938). To further elaborate knowledge can be shared among a group of individuals even though people have their own personal history of learning or even people might have come from different cultural setting. This particular reference suggests that knowledge emerges from social interaction and action among people, rather than from the analysis of an abstract concept. In a classroom, a child can learn by observing the actions of other students and teachers. While participating in sports or physical activities, lots of concepts could be constructed from the experiences, which we can connect with STEAM. Students' prior knowledge and experience of problem-solving and critical thinking play vital role in knowledge construction (Khan, 2019). Having paraphrased the above-mentioned statement, constructivism seems to have valued the problem-solving and critical thinking skills. Mainly while learning the concepts of science and mathematics, the problem-solving process goes along with the construction of knowledge and a critical approach to the existing knowledge always encourages the creation of new knowledge. Constructivism gives space for the prior interpretation to construct new meaning for better learning. (Mezirow, 2000).

In a conducive learning environment, a constructivist approach can be applied through several brainstorming activities, changing the sequence of activities based on requirements, letting students actively participate in classroom interactions, assigning peer work, and letting students reflect on their understanding. Constructivist learning theory, in contrast to traditional learning methods, underpins a variety of student-centered teaching methods. In this method, teachers are expected to create an open environment where students can solve the problem collaboratively and become active learners. From this perspective, teachers are facilitators, not instructors in learning. Thus, constructivism could be adopted as a meaningful and very supportive pedagogy in STEAM.

The constructivist approach plays a major role in orienting my research, as this theory helps to explore and experience the various aspects, facts, and realities in day-to-day life. We are, consciously or unconsciously, engaged in STEM activities in our daily lives, which can be used to effectively teach STEM to youngsters. Students will develop skills in observation, measurement, classification, communication, and experimentation, which align with a constructivist approach. Students can be involved in various experiments, research work, and projects through which they can relate to the constructivist approach in science education.

In constructivism, learners construct meaning and knowledge from their experiences because learning is a dynamic, social process. (Driver & Asoko, 1994). The constructivist view of learning argues that students do not come to the science classroom empty-headed but arrive with many strongly held ideas about how the natural world works. Moreover, active interactions between the learner and students, as well as hands-on activities and inquiry-oriented instruction, help students develop conceptual knowledge. Andersson (2001) states that solving everyday life problems scientifically deepens the meaning of scientific concepts. This has been well mentioned by the constructivist approach, where everyday life problems have been analyzed to understand the concepts.

The constructivist approach positively affects the improvement of science skills and scientific attitude. In the process of learning science through daily activities, students will be able to construct knowledge aligned with the curriculum and make real-life connections to develop a deeper understanding. This will also develop interest in the subject matter and help orient students to study subjects like science and mathematics.

In this, I used radical constructivism more as the idea that knowledge is constructed in each individual’s mind (Von Glasersfeld, 1995). This theory holds that learning is constructed by the individual and that there is no objective answer to a question.

Even after decades of transformation in education, schools around the world remain teacher-centered, with lecture-based classrooms. In such a case, the teacher's information flows from the teacher to the student. In contrast to this, Vygotsky maintains a meaningful and productive collaborative activity where both teachers and students are engaged. In this process, learning occurs through play, and formal instruction takes place between the learner and a more experienced learner (Vygotsky, 1978). Thus, teachers’ assistance is crucial to promote students' growth and skill development through interaction with society, as cognitive development is deeply rooted in social interaction and cultural context.

A key concept of this theory is the Zone of Proximal Development (ZPD), the gap between a learner’s ability to perform a task independently and what the learner can achieve with the help of a more knowledgeable other, such as a teacher, peer, or adult. This theory also highlights the importance of social interaction, cultural context, and guided learning, making it highly relevant for learner-centered, collaborative, and inquiry-based approaches such as STEAM education. Scott & Palincsar (2013) cited the statement given by Vygotsky as “The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 85).

Empirical Review

The empirical aspect of the research is vital, as it is supposed to connect with reality and practice, not only with the theoretical claim. In my research, the use of STEAM pedagogy will be practically observed to determine whether it is truly beneficial for students and the entire education system.

A study by Taylor (2022) in his research paper “Transformative Science Education” has focused on implementing science education for sustainability by exploring the emerging issue and developing solutions. Transformative education is democratic and empowering, and equips science education practitioners with advanced knowledge and skills.

While reviewing the research by Adriyawati et al. (2020) in the article "STEAM-Project-Based Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning". The research was conducted among 30 grade 4 students at a public elementary school in West Java, Indonesia, using interviews, classroom observation, reflective journals, and scientific literacy tests as data collection methods. In this qualitative research, STEAM was integrated into science and implemented through reflection, research, discovery, application, and communication. The article investigates the importance of integrating STEAM with project-based learning to improve scientific literacy among elementary school students. The STEAM-PjBL was applied in a real classroom setting to examine how this model influenced students' ability to use scientific concepts and reasoning in meaningful contexts. This further helps explore learners' development in understanding scientific ideas and in affective aspects such as curiosity and problem-solving. The study showed that STEAM–PjBL had a positive impact on students' scientific literacy across several dimensions. Students perceived core scientific ideas on alternative energy by applying knowledge in real contexts. Also, students were involved in several projects, and through these projects, they showed excitement, curiosity, and enthusiasm. Moreover, they connected concepts across disciplines, which led to enhanced higher-order thinking and affective growth. In this, students were involved in several projects, and through these projects, they showed interest, excitement, curiosity, and enthusiasm.

I have reviewed the research by Hadinugrahaningsih et al. (2017) in the article "Developing 21st century skills in chemistry classrooms: Opportunities and challenges of STEAM integration," published in Universitas Negeri Jakarta, Jakarta, Indonesia, among secondary school students. The purpose of the research was to investigate how integrating STEAM into secondary chemistry classrooms could help students develop 21st-century skills. The research focused on a STEAM-based approach that enhances essential competencies needed in today's world, such as creativity, critical thinking, collaboration, and communication. Also, the research focused on understanding the opportunities and challenges faced by teachers and students during the implementation of STEAM, which was combined with project-based learning to support deeper learning in chemistry topics, such as hydrocarbons, petroleum, solubility, and acids and bases.

The qualitative case study explored students' learning experiences by providing opportunities to design and work on chemistry projects, and data were collected through classroom observations, student interviews, reflective journals, and rubrics. The key findings were the development of 21st-century skills among students, including critical thinking, creativity, problem-solving, collaboration, and leadership. They increased their ability to analyze, evaluate, and innovate as they worked through chemistry projects and real-world challenges. The entire STEAM-integrated, project-based learning process empowered students to become more responsible, creative, and innovative, and to contribute to the sustainable development of a better tomorrow. However, the researcher encountered challenges in implementation, including curriculum integration, time management, and teacher adaptation.

Going further, an empirical review, I have analyzed the research by Tresnawati et al. (2020) in the article "Learning Science through STEAM Approach (Science Technology, Engineering, Arts, and Mathematics) Integrated Ethnoscience in the Context of Batik Culture for Pre-Service Teachers of Primary Education" among primary students of Indonesia. This paper presents the design of science learning through an integrated STEAM approach to ethics in the cultural context of Ciwaringin batik for prospective elementary school teachers. The main focus of the paper is that education cannot be separated from social and cultural aspects, and that ethnopedagogy is used to support the education and development of teachers. This article further discusses how STEAM education provides an opportunity to integrate the various streams to develop products, processes, and systems required for daily life. This research seeks to identify the connection between public and scientific knowledge through local use of products, thereby increasing awareness of the importance of local culture and the conservation of living natural resources.

Another paper I have reviewed is "Use of School Gardening as STEAM Pedagogy: A study Through Participatory Action Research" by Pant (2023) among the students of Shree Janahit Secondary School, Namobuddha, Kavre, Nepal. The paper focuses on school gardening as a STEAM pedagogy in a real school context. This shows how a garden acts as a learning space that integrates Science, Technology, Engineering, Arts, and Mathematics.

Through PAR, all teachers, students, parents, and community members were involved as co-researchers in collaboratively designing, implementing, and reflecting on STEAM gardening activities. The research study showed that school gardens provide meaningful contextual space where science and other STEAM disciplines can be integrated with real-world issues and ecological literacy.

This research showed that school gardens provided meaningful contextual space for integrating science and other STEAM disciplines with real-world issues, ecological literacy, and local socio-scientific concerns. Learners engaged more deeply in authentic STEAM learning tasks than in traditional settings, where students developed 21st-century skills such as problem-solving, collaboration, and creativity. The PAR highlighted the value of local resources, unlike conventional education.

Research Gap

Despite reading several research articles and papers on STEAM and its relevance in science teaching, I identified a significant gap in how STEAM pedagogy practically supports teachers in their science classrooms and facilitates students' learning. Most existing studies emphasize theoretical frameworks and outcomes but offer limited insight into teachers' day-to-day classroom practices. My aim is to research the contextual and practical uses of the STEAM approach in science teaching, which I have not yet found.

While going through the empirical review, several related research studies have been conducted related to science education and STEAM, where the research was based on project-based learning for developing broader perspectives, or it is focused on developing 21st century skills, or it may be to connect science with social or cultural context and transformative learning. However, I could not find research that connects learning to real life, where students apply new knowledge and skills to solve real-world problems. Hence, I would like to prioritize contextual learning for learners, with a focus on developing problem-solving skills through a constructivist approach.

Despite several efforts in the education sector, Nepal's science education is lagging in many ways, as various obstacles, challenges, and problems stand in the way of science education. Improvement of science education at the school level and university level has not received comprehensive and sustained discussions among different-level stakeholders (Paudel & Rajbhandary, 2022). The discourse prominently features science education reform, which is not highlighted in government policy and programs. The science education curricula in school to university education are highly loaded with factual information delivered through a lecture-based method that emphasizes memorization and rote learning. The science education curricula from school to university are heavily loaded with factual information, delivered through didactic, teacher-centered lectures that emphasize memorization and rote learning. Assessment encourages reproduction of knowledge.

CHAPTER III
RESEARCH METHODOLOGY

Research methodology is the key structure of the research that organizes the objectives, process, and findings within a particular academic framework. Research methodology refers to the research designs, processes, approaches, and procedures used in an investigation to discover something. In this research, we used a qualitative method, which enabled me to design, conduct, and interpret the findings subjectively. We hoped the qualitative approach would provide academic justice to my research, “Enriching Science Education Through STEAM Approach”.

We made it participatory action research. We not only observed and studied to determine the research results, but we were also actively involved with students and other teachers in carrying out action research. Observation and analysis of classroom activities, group discussions, questionnaires, in-depth interviews, reflections, etc., were key tools to support the descriptive and interpretive case study.

Research Paradigm

Research work was expected to construct a particular meaning out of the research process. The research paradigm is an academic lens to view the world from a particular belief. As noted by Guba and Lincoln (1994), the research paradigm is a basic set of beliefs or worldview that guides research action or an investigation. Thus, a paradigm guides the researcher in constructing meaning for the particular research topic.

A research paradigm depicts the researchers’ interest in the world they want to live in and the world they are living in (Lather, 1986). It includes values, beliefs, or principles of the researcher's worldview, or can also interpret how the researcher wants to develop and how the world is understood in a specific way. This means the research process is influenced by the researcher's values and beliefs. Here, the research paradigm shows the ideas of the researcher, which s/he use to draw on theories or philosophy.

In this particular research, I was guided by some research paradigms that helped me achieve the objectives and answer the research questions. Based on the nature and requirements of my particular research, the basic paradigms I followed are Interpretivism and Criticalism.

Interpretive Paradigm

Interpretivism is an approach based on philosophical phenomenology, in which people gain knowledge through subjective experience of the external world (Sandberg, 2005). When it applies to education, it asks the teachers to be reflective and to develop a better understanding of students. It encourages reflective inquiry into the identities of both learners and teachers by posing questions such as “Who are the students?” and “Who is a teacher, in fact?” (Palmer, 1998). This enhances teaching pedagogies and adapts student-centered, constructivist approaches.

Interpreting classroom phenomena yields an outcome for the researcher, guided solely by subjective analysis. The interpretation is key to my research, as I want to examine the feasibility and effects of using STEAM pedagogy in science learning. It is not possible just to see the quantitative data and analyze the findings in an objective way. Thus, the interpretive paradigm was a key to gaining the objective in my qualitative research.

Tayler and Medina (2011) have argued that this paradigm has led to a deeper understanding of other communities, enabling researchers to understand participants' cultures and to stand in their shoes to develop empathy, as it is highly influenced by anthropology. As I tried to examine the STEAM pedagogy in science teaching, we had to think not only from the teachers’ perspective, but also the understanding and perspective of the students was very important. As a researcher, we had to be empathetic in conducting this research, given the interpretive paradigm’s value. In this process, researchers were part of the subject to study the phenomena of the subject for the meaning-making process and construct meaning of the subject with others, and find the reality by constant interaction with the participants.

This paradigm helped me know my participants (students) from inside, their cultures, values, beliefs, thoughts, and will help me look at the subject (science) from their perspective as all these factors affect the learning process and learning outcome. Our participants could construct various meanings of STEAM pedagogy, and we could immerse myself deeply in their thoughts to gain reality checks from their perspectives. As a researcher, we understood and experienced through observation, analysis, and interviews, and interpreted the output. This paradigm helped us address the first research question *“How does STEAM pedagogy engage students in meaningful science learning?”* as it seeks to understand students’ and teachers’ lived experiences, perceptions, and meanings rather than measure outcomes, unlike quantitative research. Moreover, the learning that happens here is also through social interactions and meaning generated through interaction, reflection, and classroom practices.

Critical Paradigm

Academic research is not only about reporting phenomena but also about analyzing them critically. Hence, as a researcher, we did not only simply analyze, observe, and evaluate the outcome of my research but also made sure our research participants/ students are empowered in terms of becoming more critical thinkers, analytical, creative, and imaginative. This paradigm helped enhance inclusive education, where all participants have equal opportunities in the learning process. As per Lincoln & Guba (1994), participants (students) are allowed and encouraged to take an active participation through presentations, reflection, activities, etc. Reeves and Hedberg (2003) mentioned "The critical theory seek to deconstruct the 'hidden curriculum' or 'text' and search for the 'truth' and 'understanding within the social context" (p. 33). As this paradigm helped reveal participants who were more subservient, it motivated them to share their understanding and experiences and helped them tap into their hidden potential. They also raised their awareness against the unjust teaching practices, enabling them to better analyze pedagogical practices for themselves. Critical action research can be a tool to uncover injustice and unfairness, bring about change, and help improve an unbalanced social system (Asghar, 2013). Thus, the critical paradigm is integrated into our research, as I have analyzed and interpreted STEAM pedagogy in science learning. Thus, this paradigm is more connected to the second research question, *"How does STEAM pedagogy integrate art and creativity in the science classroom?"* as learning goes beyond the classroom practices. Also, traditional boundaries between subjects are challenged, empowering students to make science teaching inclusive and creative forms of learning.

Philosophical Considerations

Any research is guided by a particular philosophical perspective. Philosophy provides a wide-angle view of the world, allowing several theoretical lenses to be held. Philosophical assumptions are typically the first idea in developing a study. Some of my philosophical considerations for the generation of knowledge based on our experiences, beliefs, imagination, perception, and value are epistemological, ontological, and axiological assumptions. The philosophy of student-centered learning, or progressive learning, influences this research. The prime belief that supports this research is the learning is a social construct in which the fact and opinion are connected which means science is everywhere in real-life but not limited in single discipline. The use of STEAM pedagogy in science learning or teaching is also guided by modern educational philosophy, which keeps the child at the center and aims to make learning easy and effective.

Ontological Assumptions

People understand reality in different ways that reflect individual perspectives. As it is believed that there are multiple realities, there are multiple ends of the phenomena, and we would like to approach them through multiple teaching methods/ practices for a better outcome. This research study adopts a constructivist–interpretivist ontological stance, assuming the reality is socially constructed, multiple, and context–specific. Several meanings related to science education and STEAM were developed through student interactions and experiences in the classroom. Aligning with the PAR principle, participants are not merely passive subjects but actively construct reality and knowledge in collaboration with the researchers. Reality and knowledge are generated through collaborative engagement between researchers and participants, where multiple perspectives coexist and are continuously negotiated through practice and reflection (Upreti et al., 2024). Thus, to reflect the participant's reality and experience, we were guided by this particular assumption.

Epistemological Assumptions

The term episteme means knowledge and describes how we come to know something. In this research, the researcher comes closer to the participants, and knowledge is gained through subjective experiences of the people. From the perspective of knowledge being viewed as interpretive and context-bound, reality is understood through participants' interpretations, and the researcher seeks to understand the meanings as they are constructed and expressed in practice (Acharya, 2025). Aligning with the research, this study assumes that the knowledge is developed through an understanding of participants' meaning, subjective experiences, and social contexts, rather than through the discovery of a single objective truth. Thus, the more time they spend with their participants, the better they can understand what they know and what they need to know. However, I believe knowledge is subjective as experiences among the participants vary as they explore and interpret in different ways.

Axiological Assumptions

Axiology concerns the values in qualitative research, and value takes “pride of place” and is perceived as “ineluctable” in shaping its findings (Guba & Lincoln, 1994). It is the value that the researcher carries for participants and other actors in the research. In this assumption, the role of participants cannot be overshadowed. Researchers acknowledge that research is value–laden and biased. Thus, it characterizes the qualitative research. It includes the theory of ethics and aesthetics. In this study, participants (students) play an equal role in research as they are inseparable, and their perceptions and interpretations are equally valued. To further ensure axiological honesty and minimize bias, we engaged in continuous systematic reflective journaling using triangulated qualitative data from multiple sources. Moreover, participants’ voices were interpreted alongside observable classroom evidence rather than assumptions throughout the analysis.

Research Method

For conducting smooth research operations, a research method is essential as it makes research more efficient. Here, we have used participatory action research, in which our beliefs have helped us to examine and improve our practice and pedagogy of teaching while using STEAM pedagogy in my classroom. Thus, a participatory and collaborative approach is used, in which knowledge is created through action and application. In action research, findings emerge as action unfolds; they are not conclusive or absolute but ongoing (Koshy, 2010). We strongly believe that action research provided academic justice for my research because we examined the possibility and effectiveness of STEAM pedagogy in science learning, which I consider an action.

Participatory Action Research (PAR)

PAR projects are contextually-specific; they are focused on “what happens here, in this single case–not what goes on anywhere or everywhere” McTaggart et al. (2017). So, the study is conducted among a particular group of students as participants, which makes the method, action, and context better.

The principles of participatory action research encourage everyone to be involved in the research endeavor to “excavate and explore disagreements and disjuncture rather than smooth them over in the interests of consensus” (Torre, 2009, p. 3). Perhaps this helped reflect on and improve ongoing practices for better pedagogy and a better tomorrow.

This study takes on PAR as its methodological framework to enrich secondary school science education through STEAM pedagogy. I, along with my co-researchers, have tried to identify challenges in student engagement, creativity, and integration in teaching. Through PAR, these issues are systematically explored in collaboration with students and fellow teachers, ensuring that the research problem emerges from authentic classroom realities (Kemmis & McTaggart, 2014).

The PAR approach is suitable for this research as STEAM pedagogy itself emphasizes collaboration, creativity, and problem-solving. By engaging participants as co-researchers, this study aligns pedagogical innovation with democratic research practices. Ultimately, the use of PAR in this study not only seeks to improve classroom practices but also contributes to transformative science education by bridging theory and practice and informing broader education reforms.

This study emphasized ownership and empowerment in participants throughout the process from planning to implementation and evaluation. Students and teachers were engaged as active participants rather than passive subjects. The integration of the arts and ICT helped learners express their ideas and creativity, fostering a sense of agency and voice in science learning. As a result, the student developed confidence, responsibility, and ownership of their learning. Thus, this PAR has provided a shared power relation among all the teachers and students involved in this research. This aligns with PAR's core values, as knowledge is co-constructed and becomes a transformative process for both teachers and students. Kemmis et al. (2013) highlighted that participatory action research is grounded in active participation, collective ownership of the research process, and the transformation of educational practice.

Applying Participatory Action Research in the Context of Our Classroom

We believe students gained in-depth knowledge, developed skills, and developed social and emotional awareness. In addition, we grew personally and professionally, and also developed collaborative inquiry through immediate actions.

Participatory Action Research is considered to be a democratic, liberating, life-enhancing qualitative method that plays a major role in equity and justice (Koch & Kralik, 2009). Hence, it’s a cyclic process of research, reflection, action, further inquiry, and action for change for both society and individuals. It plays a vital role in education, teacher education, curriculum development, and educational research (Elliot, 1991).

Need Assessment for PAR

We started with a need assessment of the students, who had much higher expectations for science learning. Assessing students helped us to identify changes in understanding, skills, collaboration, and attitudes during the implementation of STEAM-based activities. We also asked about their previous experiences and the methods they used while learning science. They have been sharing that they want more interactive, engaging, and fun learning, with opportunities to explore beyond the classroom. We tried to intervene and interrogate the students about the collaborative learning in the classroom. We collaboratively planned with co-researchers. Therefore, assessment plays a crucial role in generating meaningful data to support students' learning and reflective growth.

After understanding the students' needs and expectations, we met with the school's Vice Principal to discuss the STEAM workshop we wanted to arrange. The meeting focused on scheduling an appropriate time, arranging the venue, ensuring the availability of the materials, and the smooth implementation of the workshop. This workshop aimed to support the pedagogical goals, thus creating a supportive environment for effective STEAM professional development. On behalf of the STEAM department here at the school, the school's vice-principal wrote an email to all teachers inviting them to participate in the workshop.

Conducting a professional development session for teachers at a reputed school who are well-versed and experienced in modern pedagogy presented a unique challenge. The teachers are confident, professionally up to date, and skilled in using innovative teaching strategies. Thus, to ensure meaningful participation, careful facilitation was given greater weight than traditional PD approaches. There was enough collaborative learning space, with a mix of technology that emphasized peer learning and reflective dialogue. The teacher's prior knowledge was highly emphasized, and they shared classroom experiences in which co-learning built trust and openness. STEAM education promotes students' engagement and inquiry, authentic applications, and active learning environments, which require teachers to seek appropriate pedagogical training, which cannot occur in conventional settings (Milara & Orduña, 2024).

Mushroom Farming

After selecting Participatory Action Research as our research methodology, our next task was to plan a project that would be relevant across different subjects and interesting to students as well. We wanted all the participants to engage joyfully in the project and achieve meaningful learning. At the same time, we had the research we needed to accomplish in mind, with a specific objective. Among several concepts, we chose the mushroom for several reasons. The first reason for selecting mushroom farming was that it was included in the Nepal government's grade nine curriculum. Mushrooms are one of the concepts in grade nine science and technology curriculum. The second reason was that we thought the students of the urban community would enjoy farming activity, which they usually do not do at home. The third is that mushrooms are commonly consumed as a nutritious food. Students would be interested in dealing with things that they use in their real life, as it is easy to grow in a low scale and convenient to handle. The next reason we found was that mushroom farming could also be connected to other subjects.

In this way, the mushroom farming happened to be the core activity of my research, along with several integrated activities. We believe we could actively engage students in mushroom farming, participate with teachers or co-researchers in related activities. And we could experience the implementation of STEAM pedagogy in science learning, meaningfully meeting my research purpose.

Workshop and Collaborative Discussion

To proceed with the research, we conducted a STEAM workshop for teachers in grades 6-10, during which they actively shared their ideas and discussed various aspects of STEAM education. During the workshop, teachers not only shared their ideas but also showed interest in working with STEAM pedagogy. The workshop explored various ideas for applying STEAM pedagogy to different concepts, which could be integrated across subjects. Later, we had collaborative discussions with grade nine students and finalized mushrooms as the core concept for the STEAM project.

Problem Identification

As an educator, we think about the everyday needs of the children in our class and find ways to support each child to be their best. Identifying the problem helps develop the research questions and take the necessary actions for better outcomes. In this process, we identified the major difficulties students faced in achieving meaningful and authentic learning. The main problem in teaching and learning is identified as a teacher-centric approach, in which students have no role in meaning-making and are merely passive listeners. In addition, science is considered to be an independent subject with no connections to other areas or disciplines.

Planning

We planned a procedure for applying the STEAM pedagogy. First, we identified the problem to improve practice and develop knowledge among a particular group of students. In our plan, we included the transformative approach, the constructivist method, and the implementation of various forms of art, such as music, drama, role-play, and painting. We educated the participants about the research, as it is time-consuming for full participation and commitment (McDonald, 2012).

Action

"The actions of research teams mature as individual cycles of the study grow in complexity" (James et al., 2013). Hence, with continuous cycles of action and reflection, the researchers and participants empowered themselves and the whole community. In this step, the planned design is implemented in two phases over two weeks. Pilot testing is done to understand the feasibility of the research. Throughout the design implementation, we collected information through observations, interpretations, interviews, and focus group discussions.

Reflection

"Reflection is the motor that makes the PAR cycles turn (James et al., 2013). Reflection is one of the major steps in learning through experience, carried out critically. It helps identify flaws and guide us in improving practices in the future for the betterment of the education process. In our approach to applying PAR factors, sustainability is a crucial factor. The STEAM pedagogy implemented is sustainable and can be revisited for improvement.

Observation and Analysis

In this reporting of outcomes, various methods are used to evaluate and disseminate the feedback. After data were collected through several procedures, data were transcribed it into readable text. Then the transcribed data were coded into possible themes.

Participation and Study Location

I selected Participatory Action Research as the research approach, which required me not only to conduct the research as an outsider but also to participate in the research process. In fact, we had to be involved in the research process, participating actively in the STEAM project. Then, we chose our regular grade nine students as the participants. We purposefully chose 12 key participants from grade 9, among whom 7 were girls, and 5 were boys, to reflect diversity in gender, ethnicity, and academic achievement. My colleagues/teachers (co-researchers) and my students (participants) were selected for the study. We tried to include all the subject teachers of the grade nine students, with whom we could collaboratively work in the STEAM project from the beginning. Similarly, we selected some students at random, ensuring we included both male and female students. Similarly, we included high, average, and low achievers in my participant group. But somehow, we worked with all the students in the class. The location I selected was a secondary school in Khumaltar, Lalitpur. The school is one of the reputed institutions of the Kathmandu Valley and a progressive school that closely aligns with the principles of STEAM education. I chose this school because I currently work there. As a result, we gained direct access to the classroom context and participants. We also gained firsthand experience of the challenges students face in science class.

PAR Cycle

As PAR was selected as the research method, we had to plan and implement all the pre-, during, and post-research activities in a particular way. Baum et al. (2006) argue that PAR is a strong research method, including the active application of ideas, active participation by participants, gaining experience through action, and critical reflection at the end to empower a community. Similarly, Nhamo (2012) notes that PAR involves a process that begins with identifying the problem, followed by learning-by-doing. In such a problem identification-by-and-learning process, several steps are formally organized into a PAR cycle. The Mushroom project, which we planned and implemented, is clearly presented in the PAR cycle below.

Cycle 1: Phase I

During cycle 1, we followed the steps outlined below.

Identification of the Problem

In the beginning, the problems were identified as a lack of an interdisciplinary approach in science teaching and highly teacher-centered practices in classrooms. We found that students were passive to learn scientific concepts due to limited opportunities for real-world application and experience. The teachers' reflections and discussions with teachers and grade 9 students helped us diagnose those problems.

Planning

After identifying the problem, we planned to intervene in the science teaching and learning approach through STEAM pedagogy. The mushroom farming process was implemented as a project to teach STEAM pedagogy to grade 9 students, in line with the national curriculum. We connected the learning with real-life contexts, integrating multiple subjects. We planned and conducted a STEAM workshop for teachers across different subjects to design activities for the STEAM project together.

Implementation

We initiated the planned activities through a teachers' workshop and discussion with students. Teachers presented ideas for integrating different subjects into a single project. Similarly, students participated in finalizing the mushroom farming STEAM project for learning.

Observation to Collect Information

During the workshop and discussions, it was observed that not only the students but also the co-researchers (teachers) were highly engaged, collaborative, and highly interested in implementing STEAM pedagogy.

Implementation: In this stage, the action of the first cycle was successfully accomplished. During this process, we collaboratively conducted the following STEAM approaches;

- A day long trip-based learning to a mushroom farm, enabling students to observe
- Integrated learning across all disciplines;
    - Students explored a farm, enabling students to observe real- life mushroom cultivation practices.
    - Computer students designed a basic website presenting information on mushrooms.
    - Arts students created mushroom house models using clay, chart papers, digital art, and other creative projects.

This has encouraged collaboration, inquiry, and hands- on engagement.

Reflection

We concluded this cycle by reflecting on the problem identification, the plan, and its implementation. After the reflection, we were confident in our selection of mushroom farming as an authentic and engaging context for STEAM learning. During the reflection, the feedback from teachers and students supported improving the activity design and the implementation of the plan. The gaps as limited depth in practical cultivation and need for more sustained hands- on activities were identified.

Cycle 2: Implementation Phase

In cycle 2, we went through similar steps as cycle 1, but with new experiences as mentioned below.

Identification

After reflection on cycle 1, we identified the need to assess whether the planned STEAM activities were practically implementable and how they affected students' engagement and learning.

Planning

We developed the implementation plan for another cycle, incorporating constructivist and transformative approaches. In this process performing arts such as role-play, poem on mushroom and more rigorous, intensive, and practice-oriented hands- on activities were designed.

Implementation

We implemented mushroom farming in phases. First, we did piloting followed by full execution. Students and teachers are actively engaged in hands-on activities, integrating the tasks to make learning the concepts of different subjects. During this process following actions were performed;

- A 3- day rigorous hands- on mushroom cultivation process was performed within the school with locally available resources.
  - Preparation of substrate
  - Inoculation and monitoring
  - Understanding hygiene and environmental control
- Students actively participate in the complete cultivation cycle
- A STEAM Expo was organized where students presented
  - Mushroom cultivation procedure
  - Websites on mushroom
  - Artifacts and models
  - Other STEAM projects as satellites, oobleck and many more

Reflection

As we reflected critically, we found the information indicating students' active engagement, meaningful learning, and strong integration among subjects. Similarly, we found the sustainability of STEAM pedagogy guiding further refinement and future application of the approach. The STEAM Expo has promoted peer learning, communication and public presentation.

Data Collection Tools and Approaches

For my research, I used a few tools to collect data from my participants. Later, I derived the meaning of STEAM pedagogy from that information. Observation, formal and informal conversation, and field diary were the major tools that I used during the STEAM project.

In qualitative research in education, data collection tools such as interviews, observations, and focus group discussions are the foundation for capturing rich and contextual insights into how students learn and how teachers practice pedagogy in teaching. Several tools for quantitative research serve complementary purposes: interviews evoke individual experiences, focus groups help uncover shared meanings, observations provide authentic, contextual data that words may not be enough for, and field diaries interpret educational artifacts. If these tools are used properly, they enhance the depth and credibility of qualitative findings. To ensure credibility, we used multiple sources as mentioned above. Also, triangulated qualitative data strengthen the validity by combining classroom observations, students' reflections, and teachers' interviews (Denzin, 2017). Aligning with the statement, our research has employed the triangulated data through classroom observations, students' reflections, and teachers' interviews to ensure findings on the project and STEAM learning were valid, creative, and deeply reflective of classroom realities.

Observation

For the research, during the entire STEAM project, from the classroom to the mushroom farming area, I observed what students did and how they were involved in each and every step of the project. I observed the participating students and teachers in the classroom and in the field, and later tried to make sense of what I had seen.

Formal and Informal Conversation

In addition to our observation, I had several conversations with the participating students and teachers to collect the required information. We involved the participants in formal and informal conversations in the classroom and even in the mushroom field. Those conversations were held before the STEAM project began, during the project was going on and even after the project ended.

Field Diary

For our research, we used the information I collected during the STEAM project as raw material, and I was very conscious of recording every minor and major observation. For that, I took the notes in my field diary. But I did not use only the paper diary as an information collection tool; I also used my cell phone to take photographs of the work and record sound and visual clips of the project. In addition, everyday reflective journals of the tasks helped us to plan, improve, and execute for the next day.

Meaning-Making Process

The outcome and findings of the research make an argument that can support creating meaning in the related field. This qualitative research tries to generate some thematic and pedagogical meaning in the field of science teaching and the STEAM approach to learning. The interpretation is developed through the nexus between the research background, related literature, and the information collected from the field. During the research process, arguments and interpretations were carefully developed to generate meaningful insights from the information.

After we collected the information using the tools mentioned above, we transcribed it into my computer. As the STEAM project was over, the firsthand information was transcribed into the academic writing required for the dissertation. We tried our best to connect every piece of information to the research theme and research questions. In this study, audio recordings of interviews and interactions were transcribed verbatim, capturing participants' exact words to preserve meaning and context. Verbatim transcription is a word-for-word reproduction of the interview and is considered to enhance the rigor and accuracy of the data but can delay the availability of research findings (Hill et al., 2022). Further thematic manual coding was prepared and analyzed to maintain the accuracy. Similarly, we tried to make qualitative meaning from the information we collected.

Quality Standards

Andrews and Halcomb (2009) define trustworthiness as, 'The degree of confidence that the researcher has that their qualitative data and findings are credible, transferable, and dependable" (p. xvii). In qualitative research, trustworthiness comprises credibility, dependability, conformability, and transferability.

Credibility refers to the truth values that are set out to be inquired into (Cohen et al., 2018). Credibility establishes trustworthiness and determines how consistent the finding is with reality. Transferability requires the researcher to provide sufficient data and context to enable the reader to judge whether the findings can be applied to other contexts and situations. For dependability, sufficient data and documents are required for scrutiny and replication.

Confirmability ensures that the study findings result from the experiences of the informants rather than the researchers' preferences and can be achieved through a sequence of records.

Transferability refers to findings that can be applied to other settings or groups (Polit & Beck, 2012). Results relate to individuals, not to the study, and can be associated with their own personal experiences.

As stated by Polit and Beck (2012), Authenticity is the ability and extent to which researchers express participants' feelings and emotions in a faithful manner. And in this process, readers get a sense of the research experience.

Thus, to maintain all these trustworthiness criteria in my research, we used the research process formulation, data analysis, field notes, etc. We critically analyzed the research process and the result. Moreover, we included participants' responses, which may often lead to wrong interpretations of the findings. Also, we checked for the stability of the results that were performed on the same subjects in the same context for dependability.

Ethical Consideration

Ethical considerations focus on protecting participants and ensuring responsible research practice. Before beginning my research, I took verbal consent from the Principal and Vice principal of the school. As I have considered ethical considerations in our research, I have obtained informed consent from participants, ensuring voluntary participation. We also respected their confidentiality by using pseudonyms, keeping them anonymous, and hiding their identities in pictures and other information. Our research will cause no harm, and we respect participant voices and cultural context, aiming to benefit learners. Hammersley and Trainou (2012) mentioned "Ethics means 'a set of principles that embody or exemplify what is good or right, or allow us to identify what is bad or wrong" (p. 16). It is a set of principles that guide our research design or practices.

Chapter Summary

This chapter presented the research methodology adopted for this study, which mainly focuses on enhancing science education through the STEAM approach via PAR. The PAR allowed researchers to collaborate with the students, teachers, and other stakeholders to identify challenges in teaching, implement strategies, and evaluate outcomes. It also described the research settings, along with details of participants and co-researchers, and this research is guided by Criticalism and interpretivism as the basic paradigms. The data collection methods were interviews, reflective journals, and students' work samples, and credibility, trustworthiness, and ethical considerations were ensured.

CHAPTER IV
STEAM PEDAGOGY AND STUDENT ENGAGEMENT IN MEANINGFUL LEARNING

This chapter presents the demographic information for the co-researchers and participants, followed by a comprehensive discussion of their involvement and engagement in the STEAM project we designed for this research. The information we collected during my research have been analyzed in this chapter. The chapter has been divided into six different themes and discussed accordingly. All the themes try to address the first research question, which asks how STEAM pedagogy engages students in meaningful learning of science. This chapter emphasizes how students have actively participated in designing, creating, experimenting, and reflecting, fostering curiosity and ownership of learning. At the end of the chapter, the relevant theoretical connection has also been presented.

Profile of the Primary Co-researchers

We (five subjects' teachers from grade nine) collaboratively decided to plan and implement STEAM approach for our research. Then, identifying the gap, we organized a professional development session or workshop for the teachers to clarify the STEAM concept and its implementation for grade IX students. Below here is provided a brief introduction to all four co-researchers, using pseudonyms to respect their identities.

Sambidda

Sambidda is a very hard-working Nepali teacher, very passionate about teaching. She has completed her Master's degree in Nepali language and literature and has more than 20 years of teaching experience. She is much fond of students and vice – versa. She has completed a course in MC and does an excellent job in it. She has been playing a vital role in nurturing the students with care and compassion. She has a strong work ethic, values every student, and supports them in their needs. It was much easier for me to work with her, as she was very cooperative from planning through implementation. She also contributed to enriching the lesson plan and making the process a success. She said that "*Nepali bhasa bisaya padauna dherai garho huncha. Bidyarthiharoo nepali bhasa lai dherai prathamikta didainan tara bigyan bisaya sanga jodera padauda bidhyarthi lai Kareshabaari bujna dheari sajilo* *bhaayo*" (Trans: Teaching Nepali language and arts is a tough job as students prioritize less the Nepali subject, but in this case of integrating the topic Kareshabaari with science (Mushroom farming) really helped students to understand the in-depth concept about the topic).

Vidusi

Vidusi is a Computer Science teacher, very young, energetic, and enthusiastic, with 2 years of experience in the teaching field. She is 27 years old and is somewhat new to teaching, yet she has developed confidence in a very short time. She is very technology-savvy and can easily resolve any IT-related issues. In fact, she is very smart, confident, and knows strategies to handle the classroom. Despite being very young, we could learn a lot from her as she is skillful in her field. Her constructive feedback and contribution of creative ideas have enriched my research process. She helped me develop a plan to develop a website named as "Mushroom farming" and students did a wonderful job while developing the website which included all the information and procedure required for Mushroom farming. During the meeting and planning with her, she shares, "*She will figure out the students who are brilliant in this job and, after having a discussion, will develop a better idea of developing a website on mushrooms*". This helped us to choose some key participants for the research. She has made a major contribution to the plan's success.

Meraki

Meraki is a very kind, lovable, and empathetic social studies teacher. She has been working with the School since August 2021 as a Junior High School Social Studies teacher, with 10 years of teaching experience. She is a warm and caring teacher who wants her students to be successful learners and, thereby, works to create a classroom atmosphere that is inspiring, encouraging, and adaptable to students' different needs. She has completed her Post Graduate in Counseling Psychology and holds a Master's Degree in Conflict, Peace, and Development from Tribhuvan University. She brings experience in progressive teaching and learning, along with the ability to create a differentiated learning environment, from her work in the International Baccalaureate program. Her experiences, from working as a development sector professional to teaching, have given her exposure to both Nepali communities and to students of varied backgrounds and abilities. She is trained in adopting various teaching methods and skills, as well as incorporating inclusion in teaching, through a number of training and workshops. She has the capacity to build an extraordinary rapport with the students. Students are really fond of her and love being around her, sharing their issues, updates, secrets, and more. In fact, she is a teacher cum counselor as she can convince not just students but also adults. Her words are magical; one can keep listening for hours and hours. Due to her health issues and other technical difficulties, she was not able to start our planning on time, regardless of her effort. Later, she made it a success with full dedication. In her part, where Mushroom farming was integrated with the topic of economic activities of social studies, they had to connect with trade, business, import, and economic benefits of Mushroom farming. Students had a group discussion and were assigned to present via a PowerPoint presentation, showing chart work.

Kalki

Kalki has been a calm, focused, and introverted art teacher at the school for the past 8 years. She is very much passionate about the arts as if art runs in her blood. She not only helps students' learning through art but also helps them to express ideas, feeling and emotions through various forms of visuals, such as arts as drawing, painting and other visual forms. She has pursued master's degree in fine arts and fashion design. She is so much into integrated teaching that she prepares her lesson plan based on the lesson plan prepared by other subject teachers and tries her best to align with it. She most often comes and asks me, "*We are planning to develop a mushroom house and the Basidiocarp of mushrooms in the art class, and if you have any better or additional ideas on that, please let me know. We will surely include your suggestion*". Every time during the art class, we joined her to witness and collaborate with the students to make the STEAM project a success. In the STEAM project, she helped significantly develop the creative expression of various stages and forms of mushrooms. We could see that my key participants enjoyed the meaningful learning process.

Profile of the Participants

In addition to our four co-researchers, we selected 12 key participants among grade IX students with their help. After a series of discussions and meetings, we have deliberately selected 12 key participants based on gender inclusiveness, ethnicity, and previous performance (so-called, ranging from best to struggling students). We obtained verbal consent from all key participants and assured them that we would respect their identities and obtain their consent for their photographs and their sharing. The main reason for selecting 12 participants was that the number was appropriate for our action research, allowing in-depth engagement, repeated interaction, and close observation within the classroom. The number was manageable for iterative cycles of planning, action, observation, and reflection. Also, the number helped to obtain the diverse perspectives necessary for deeper qualitative insights.

Priyani

Priyani, a 15–year–old female student of grade 9, was one of the key participants in the STEAM project. Since she has been studying at this school for 9 years, we believe she is a perfect representative of the school's students. Academically, Priyani performs excellently in all subjects, demonstrating a command of both Nepali and English. Her friends and teachers love her for her friendly demeanor and positive learning attitude. Besides her hard work and the school's effort, her parents' continuous support is also one of the keys to her sound academics.

We found Priyani to be an enthusiastic participant in the STEAM project, demonstrating a deep interest in the activities and actively contributing throughout the process. Not only did she become active in learning through the activities, but she also led her classmates during the project. We could see her dedication and commitment to both her learning and her leadership.

Rishav

Rishav, a 14-year-old male student, was currently in Grade 9 when we conducted the STEAM project. He seems to be facing academic challenges and is actively working to improve his performance across subjects. Despite these struggles, Rishav developed a strong interest in the STEAM project and fully engaged with it. Throughout the project, he asked insightful questions and showed curiosity during different phases of the activities. We noticed he enjoyed working with his friends and often found motivation through group work. We saw he preferred the hands-on, interactive aspects of the STEAM project, especially when learning took place outside the traditional classroom setting, indicating a preference for practical, experiential learning over conventional classroom instruction.

Suniva

Suniva, a 15-year-old female student, is known for her hardworking and sincere approach to her studies. She has been in this school for the last 8 years. Her sincerity is well appreciated by all the subject teachers, and her friends look upon her academic strength. Her well-educated parents are also happy with her and are kept updated on her academic performance by the teachers.

Throughout the STEAM project, Suniva not only actively participated but also remained highly engaged in all the activities designed and conducted. She demonstrated a strong interest in both the learning process and the project's goals. Her interactive and inquisitive nature gave her practical knowledge of mushroom farming. She consistently asked thoughtful questions and sought to deepen her understanding of the topics covered. We noticed Suniva having a collaborative spirit. She often helped her friends and encouraged them to join in the activities. She particularly enjoyed connecting science, art, and mathematics. She had said during the reflective sharing, "*Learning a concept through collaboration with other subjects helped her to have a better understanding of the concepts*."

Reshu

Reshu, a 15-year-old female student, is academically average but very focused on her studies. Though she is not notably interactive with teachers, she is committed to following instructions and completing tasks to the best of her ability. Her parents have no specific expectations of her, but time and again, they want her to achieve better grades in the exams.

In the STEAM project, Reshu actively participated, following all instructions carefully, though she was less vocal in group discussions. She mainly enjoyed outdoor activities, preferring hands-on experiences over traditional classroom tasks such as reading and writing. During the project, she showed greater interest in the commercial aspects of mushroom farming, focusing on its business potential rather than its scientific growth processes, indicating a practical, entrepreneurial mindset. We asked her what she liked most during the project. She answered, "*I was interested to know what profit would be gained, but unfortunately, we could not explore that part.*"

Savana

Savana, a 15-year-old female student, is an introverted, quiet student. Academically, she performs well, consistently demonstrates strong results in her studies. Her parents are pleased with her academic achievements but would like to see her become more expressive and engaged in verbal communication.

During the STEAM project, Savana happily followed all instructions and was particularly interested in observing the real-world applications. She was sincere in noting down all the activities, ensuring that she captured every detail accurately. Although she did not ask many questions, Savana completed all tasks efficiently and with great attention to detail. She found the integration of science and art particularly fascinating, appreciating how the two disciplines could be combined in creative ways. Once she had said, *"I am fond of art and learning science through art is really awesome, I am enjoying this part a lot".*

Ojash

Ojash, a 15-year-old male student, excels academically and is praised for his sincerity, respectfulness, and strong discipline. He comes from an educated family, and his parents are very supportive of his educational journey. Ojash shows a particular passion for Science and Mathematics compared to English and Nepali.

During the STEAM project, he thrived in collaborative work and enjoyed engaging with his peers in hands-on activities. Ojash showed a keen interest in exploring both the scientific aspects of mushroom farming and its potential business applications. He actively supported his friends throughout the project, helping whenever needed, including the teachers. Similarly, we saw him carefully noting down all his observations, reflecting his attentive and thorough approach to learning. He shared *"During other times my friends showed very little interest in learning, but I am glad that some students who didn't show up in learning seem to be very enthusiastic".* As the students were able to be involved on their own, they seemed very excited and engaged. The most notable pre- to post-change in participants' motivation occurred due to hands-on activities in the subareas of critical thinking, peer learning/collaboration, and expectancy, as personal learning preferences and responses remained consistent in the positive direction (Owolabi et al., 2021)

Suraj

Suraj, a 14-year-old male student, is very intelligent but not very hardworking. He achieves average exam results, but his parents expect him to do better each time. All the subject teachers suggest that he be more focused on reading and careful in writing. He joined this school when he was in grade one. His parents keep asking the teachers to support him in his academics and make them better.

During the STEAM project, Suraj was particularly excited to have the opportunity to work outside the classroom, as he is a kinesthetic learner who loves hands-on activities. He enjoyed engaging in physical tasks and was very active in planning the project, including calculating costs and analyzing potential profit and loss. Suraj took on a leadership role within his team, demonstrating a natural ability to guide his peers. He expressed happiness in stepping away from traditional book-based learning and writing, happy in the more practical, real-world aspects of the project.

Karma

Karma, a 15-year-old male student, is average academically but is known for being respectful, polite, and humble towards his teachers. He is well-liked by his friends, and while his parents are pleased with his behavior, they hope for him to improve his academic performance. Karma is strongly interested in IT and Computer science. During the STEAM project, he found the integration of IT particularly interesting, as it aligned more closely with his interests. Karma especially enjoyed the group work, taking particular pleasure in helping to design and set up the structure for the mushroom plantation, demonstrating his appreciation for practical, collaborative activities. He also made a valuable contribution to developing the website for mushrooms.

Arpana

Arpana is a 14-year-old female student. She struggles with her academics. She doesn't love writing long, descriptive answers and shows a lack of interest in reading lessons, particularly in subjects like Science and Mathematics, which results in difficulty being graded in those subjects. Her parents seem very concerned about her academics. According to them, she is poor academically, and teachers have to put in extra effort to improve her.

Despite not being interested in academics, Arpana has demonstrated a positive attitude towards practical learning experiences, particularly during the STEAM project. Throughout the project, we noticed her enjoying different hands–on activities outside the classroom. She liked studying real-world applications, which helped her engage with the material more effectively. She really liked the integration of arts into the project, as it aligned more with her interests, and she found her role in the group work meaningful. We also noticed that she showed little interest in the scientific aspects of mushroom growth or in the calculations and measurements involved in the project. Yet, she took pleasure in observing the entire project's progress. With the collaborative efforts, Arpana worked well with her friends and gained a sense of accomplishment from being part of the group. We believe the STEAM project provided her with the experience of learning in a more interactive, less traditional way, which she must have enjoyed.

Alisha

Alisha, a 14-year-old student, joined this school in grade one. Academically, she performs at an average level. Teachers say she shows little interest in studying, particularly in Science and Mathematics. Rather, she shows interest in both the language subject and Social studies. Memorizing the theoretical lesson and practicing Math and Science repeatedly is very tough for Alisha. But she enjoys putting arguments in her social studies lessons, often debating with her teachers and classmates to support her views. She is often observed spending time with friends. Her parents are supportive of her but express concern about her lack of hard work and commitment to her studies.

During the STEAM project, we did not find Alisha focusing on the scientific aspects, such as the growth process of mushrooms. But we found her interested in the collaborative and organizational side. She took on a leadership role, actively forming groups and ensuring that the teamwork was going well. Alisha thrived in the hands-on aspects of the project, particularly enjoying the outdoor activities with her friends. She was very happy not to have the usual pressure of textbooks and written exercises, which allowed her to focus on practical, group-based tasks. The thing she liked most during the project was exploring the financial and business aspects.

Pratham

Pratham, a 15-year-old male student, struggles to achieve good (relatively) grades in academics, which has caused concern for his parents. Despite struggling in his studies, he is known for his charming personality and respectful behavior among the teachers and his friends. Although he is not interested in science and mathematics, he manages to perform at an average level in language subjects. He loves group work, especially in goal-oriented projects, where he can collaborate with others and contribute to the team's success.

During the STEAM project, Pratham demonstrated strong will in the management aspects, particularly in organizing and setting up the project site. He continuously inquired about the financial aspects of mushroom cultivation, demonstrating curiosity about the business and the project's practical applications. We observed his ability to focus on the logistical and management components of the project which clearly highlights his strengths in leadership and practical thinking, even if his academic interests lie elsewhere. Pratham's interest in teamwork and the financial aspects of the project showcased his potential to engage with real-world concepts and contribute meaningfully to the project's success.

Megha

Megha, a 14-year-old female student, struggles to achieve good academic results. Her parents seem very worried about her academic performance. Despite struggling with her studies, Megha has a strong passion for art and music, areas in which she excels and finds joy.

During the STEAM project, we did not see Megha placing much emphasis on the scientific and theoretical aspects of mushroom cultivation and growth. However, she demonstrated a notable interest in group work, appreciating the collaborative nature of the project. She mainly liked the integration of art with science, as it allowed her to connect her love for creativity with a more hands-on learning experience. She appreciated the project's concept, which provided her with the opportunity to contribute in a meaningful way, something she often did not experience in traditional classroom settings. Through the project, she built up a sense of involvement and accomplishment, allowing her to feel that she is also capable of doing a meaningful job.

Analysis of the Data from the Field Work

The entire STEAM project performed by the students of grade nine from a reputed school of Lalitpur district in collaboration with the subject teachers where the students designed, created and experimented and reflected to make learning possible. The project title chosen after discussion and meeting with the co- researcher was the topic Mushroom. During the project, students observed, explored, researched, planned, discussed, worked on the project, and finally collaborated with other subjects relating to the topic, concept, and idea. Additionally, students collaboratively worked on some STEAM designs or models as a project to further enhance their learning in the STEAM subjects.

The nature of the Mushroom project was hands- on, inquiry-based, and an integrated learning approach. It was learner-centric, where students were allowed to learn by doing, applying concepts from Nepali language, Social studies, Arts, and Computer science. The experiential project was problem-solving-oriented, as they encountered challenges such as contamination, which made learning engaging and meaningful. The unique and outstanding projects on STEAM as aircraft, artificial satellites and oobleck model helped the students to delve into the broader aspect of STEAM and its benefits in better understanding of concepts of science in collaboration with other subjects. Students share their experience and belief that in-person workshops or practical sessions are most likely to promote meaningful learning, as they provide opportunities for interaction with peers and educators and for the application of knowledge and problem-solving (Andrews et al., 2023).

The interventions for this study were conducted in a progressive school where I teach. A preliminary assessment showed that students relied on rote memorization, had limited exposure to creative activities, and lacked opportunities for problem-solving, critical thinking, and collaboration. Given these challenges, interventions were designed according to STEAM pedagogical principles. A mushroom farming project served as the central interdisciplinary intervention.

During the process, students were encouraged to create models, diagrams, and creative representations of the concepts they had learned. Students work in a group to investigate problems, design experiments, and share findings. Students also explored digital tools for online data collection and multimedia presentations integrated into projects and activities. Ultimately, after each activity, students reflected on their learning and discussed challenges to overcome in the future.

Firstly, I obtained the consent of the principal and vice-principal of the school for the project work required as part of my research. After I got the green light from the school heads, we collaboratively had a meeting with the co-researchers to discuss the plan. After a short talk, we felt the need to conduct a STEAM workshop for the co-researchers and other teachers to make them a little more aware of what STEAM is. All the teachers enthusiastically participated in the process. After a few STEAM sessions, we (teachers) collaboratively developed a project plan. STEAM teacher training may be an effective mechanism for supporting teachers' confidence and ability to implement STEAM lessons, and teachers report increased self-efficacy and enhanced understanding of arts integration (Boice et al., 2021). The plan was presented to the school's principal and vice-principal. After receiving their feedback and modifying the plan based on it to improve the STEAM project, we (I, along with my coresearchers) further worked on it and prepared a final draft. The final draft was again shown to my dissertation supervisor, and after his suggestions and corrections, we finalized the plan, which was ready to be implemented. Then we selected the key participants purposefully after discussion with the co-researchers. We obtained their consent, conducted the need assessment test, and identified gaps to improve learning. Most of them had higher expectations, wanting science learning to be more fun and activity-based. They mentioned, *"It is so difficult to understand the concepts of science as the scientific terms, formulas, and diagrams are really complex."* While some other participants (students) wrote, *"We want more experiments and trips while learning science*." After the needs assessment, we began the project by checking their prior knowledge using a KWL chart. Based on the given questions, students had rich discussions, explored answers through various sources, such as reference books and google, and were asked to jot down key points from their discussions. Right after the discussion, the group of students will share their ideas turn by turn. Additional comments and feedback were given to each group to address any confusion.

Considering trip–based learning as one of the best platforms of connecting learning with the real world, students were taken to visit a Mushroom farming institute where they observed and identified several forms of mushrooms. In the case of project-based learning, field trips would be interesting to experience to understand the importance of an informal learning environment, as it better leverages the impact on learning and collaboration (Monaghan, 2015). Following the visit, students were asked to write reflections on the farm visit. Integrating with the topic "Kareshabaari" in Nepali language and arts, students had a rich discussion on the possible cultivation of mushrooms in Kareshabaari, in the presence of a Nepali teacher and me. Integrating art-based learning science, students developed the Mushroom house. Some developed with the help of clay, while others did chart paper work on it, and some developed a poem on mushrooms. They developed really beautiful varieties of mushrooms found in our community, including the stages of growth, full of aesthetic appeal. Following the Nepal government's social studies curriculum while learning trade and business, students had rich discussions and prepared a PowerPoint presentation on the opportunities for mushroom trading in Nepal. Interestingly, students developed a very rich and brilliant project "Website on Mushroom farming" in collaboration with the computer science teacher, where all the required information was easily accessible for the mushroom cultivation process.

Then comes a very important day of the project, "*The grand mushroom farming*". It took 3 consecutive days for the farming procedure under the expert's supervision. Reaching this point was not easy, though, as we had to go through several challenges, from identifying a suitable location to preparing the required materials to looking for a good mentor for the farming procedure. The 3-day long process was, although very tiring and hectic, very much fun and memorable to see how most of the students actively participated in the field work with all their efforts and energy. One of the participants (students) had jot down in his reflection as *"This* *three-day project not only gave us a deeper understanding of mushroom farming but also connected us with traditional Nepali agricultural methods blending science with culture"* and other participant (student) mentioned as *"The process also taught us the importance of cleanliness and attention required while farming to prevent contamination"*. In integrating ICT into mushroom farming, in collaboration with Nepali language students, students had to write a reflective email to the teachers and leaders about the mushroom cultivation. Due to the rapid pace of technological discoveries and the remarkable development of information technology, new possibilities and ideas can be effectively implemented in the teaching and learning process in science education (Savec, 2017). Moreover, we developed various STEAM projects (aircraft, oobleck, satellite, mushroom) for the STEAM exhibition to showcase the projects we planned and developed, integrating different subjects to clarify the integrated learning process.

The participants became more empowered as they actively participated in planning and executing STEAM activities. Their reflections showed a sense of ownership as they chose the type of ICT tool to represent scientific concepts and used their own creativity to develop models, diagrams, or projects. Their collaborative effort to work on the project, identify problems, and solve problems demonstrated increased agency in the learning process. Their voices were prioritized and suggestions were highly acknowledged throughout the process.

Experiential Learning for Developing Scientific Concepts and Fostering Deeper Understanding through Active Learning.

The first theme emphasizes experiential and active learning. Here we are trying to make meaning from the students' participation in the STEAM project and the experience they have gained through work and observation. Our research is participatory action research, which we believe is an interpretive and critical research paradigm that allows experimentation and the construction of meaning. As Lincoln (1994) states, the research paradigm is a basic set of beliefs or worldview that guides research action or an investigation. Here in this research, we are investigating the actions of the students, and even myself.

After the students got engaged in the mushroom farming area of the STEAM project, we had planned to collect the students ' reflections on their learning. Loughran (2002) highlights science as reflection and reflection as science. Through reflection, we believe we can help students determine whether they really learnt. Also, students become critical of themselves while reflecting on their own activities. Loughran (2002) further states that reflection is a metacognitive process.

We began to take the opinions of different students in the class. My first question was

"How did you feel getting engaged in the mushroom farming?"

A girl replied,

"This project has made me active in learning, as I am engaged in all the activities related to the Mushroom project. I was never interested to learn science in the classroom because it would be difficult for me to understand the theories." From her answer, we realized that students who struggle academically rarely find science and technology subjects of interest. The theory can seem complex to many students, but it is not as complex as they find it when they get to experiment in a real-life context. In fact, science is the truth. Science exists in every discipline of learning. We mean to say students are always dealing with science. Maybe technology is a different thing. The interesting question is: even if science is connected to everyday life, why do students struggle to study it and consider it a challenging subject? Maybe how scientific rules are theorized in such difficult ways that students cannot comprehend. It means that science can be easy if students realize it exists in their everyday interactions. Thus, participating in real work and gaining experience can help one understand science deeply.

Figure 1
Packing of Hay for Mushroom Cultivation

Further, we got the same answer from a boy who said, *"I had taken the project as a boring job in the beginning, but as I got involved in field work, I learnt the mushroom farming process and found it interesting also."*

From the reflection of the student mentioned above, we noticed that when people experience something real through their own effort, some kind of learning takes root in their minds, as is commonly said: learning by doing. The two reflective narrations of the students we mentioned above support the theme that experiential and active learning fosters a deeper understanding. Hidayat & Syahidin (2019) opine that contextual learning makes students active physically and mentally. Through the STEAM project, the students could contextualize the mushroom farming from several angles, like the economy of the nation, regular food in the kitchen, flora that is easily seen around during the rainy season, and the mushroom farming area, etc. Having these many connections to real-life scenarios might increase students' interest in learning. At the same time, adolescents love to experiment, which leads to learning new things.

Learning by Doing' is one of the modern pedagogical approaches we feel is very helpful for students to learn in a real-world context, whereas in traditional teaching methods, students are never exposed to any hands-on activities or learning processes to enhance their learning. The theory of learning by doing was given by John Dewey, who described school as a social institution where learning happens through social interaction. Dewey believed that traditional education was beyond the scope of young learners, while progressive education includes socially engaging learning experiences that are developmentally appropriate for young children (Williams, 2017).

To continue the reflection session, we added another question,

"Do you think your experience in the field during the mushroom project helped you to understand the concept that we wanted to teach you?"

For a while, many students remained silent, while a few spoke in low voices. After a while, one of the participants shared

"It was so much fun, and we learned a lot by getting engaged in the project itself, and I think I got the core theme of the concept of mushroom farming mainly through an integrated learning approach in different subjects."

Figure 4
Selection of Hay with Better Quality

Another participant added, *"I don't know very clearly about* the concept, but now I *know how mushroom is cultivated in a farm."* This particular student is outspoken and speaks without any hesitation. This showed that every student has their own kind of experiences.
The reflective opinion of the students made us think about the objective of the project and the concept of the lesson related to mushrooms. Theoretically, whatever is written in the textbook, the real learning outcome should be the ability to cultivate mushrooms and clarity on how mushrooms grow, their life cycle, their importance in medicine, and their economic benefits, which we found the students gaining slowly over time. The

concept of learning by doing is well reflected in my STEAM project for the students. "Learning is a social activity - it is something we do together, in interaction with each other, rather than an abstract concept" (Dewey, 1938). In the STEAM project, learning became possible even for students who struggled in the classroom because their learning was connected to social interaction. As in an orthodox class, the lesson was imposed in isolation rather than in a small society where one could interact and learn simultaneously.

Unlike the passive reception of information, students can construct concepts by actively engaging in the learning process in a real-world scenario. Students directly get involved in the process of discovery and application. As such, when learning Newton's laws of motion, instead of just stating the laws, students can engage in hands-on activities or related experiments, which can lead to a deeper, long-lasting understanding. The learning process naturally occurs through student activities and work, rather than the transfer of knowledge from teacher to student (Hidayat & Syahidin, 2019). In my understanding and belief, learning comes from experience, as it helps bridge theory and practice. This further enhances memory and understanding, as per the saying "Learning by doing" as described above.

In the same reflection session, we asked the third question, *"Mainly, what did you like about the STEAM project and why?"*. We heard the common voice, *"everything"*. We further asked them to give specific answers. Then one of the students mentioned *"I am so glad that we had a wonderful experience in this Mushroom learning"*.

Yet, we were not satisfied with the answer. Thus, we again requested to be more specific. The reply was, *"In my opinion, learning by doing in the field was the best.* "We further asked, "*Can you specify about learning by doing?"* Then he replied, "*All the group work from planning to implementation on mushrooms through all subjects and activities helped us to have a detailed understanding of the topic,*" and I responded, *"Great."*

We could easily connect that answer with my theme, which prefers experiential and active learning over text-based classroom learning. Students got to interact with the environment using all their senses, which enhanced all types of learners. Not only did they interact with the environment, but they also theoretically connected with the concepts for their better understanding. Learners grasp information through concrete experiences and abstract concepts, and can then transform these experiences or concepts to make meaning in their world through reflective observation and active experimentation (Kolb, 2014). We totally agree with this statement as it means the abstract concepts can be concretized through real-life experiences. Those experiences can make sense to the students who are not very clear about abstract theories and concepts. When students critically reflect upon what they have done, they can make meaning out of their experiment.

As we recalled our school days, when no such things would occur. We had no opportunity to interact with the environment when it was about learning. Our learning was entirely text- and lecture-based, which required rote memorization of call lists. To answer the same question, another student spoke, "*I actively participated in all the work you asked for. The main important thing that I liked the most was I was active in learning unlike my past times where I used to be very much passive and isolated*.". Hearing such statements from the dear students really made me feel accomplished.

As students shared their opinions, we felt they were speaking with more maturity than we had seen in earlier classes. It means the experiential learning was reflected in their confidence. Experiential learning has gained momentum in education through major shift to meet the purpose of 21st century education for students' competence in self- directed learning, eco- sustainability and employability (Bartle, 2015). As they engaged themselves in activity, they began to develop an opinion, which was actually the development of critical thinking. Students directly participated, reflected their work and actively engaged which helped them to get better experiences to reinforce their understanding. Their excitement about learning outside the classroom is on a whole other level. They do not hesitate and are highly active in each stage of planning and implementation. Active participation helps learners to develop problem–solving skills, adaptability, and the ability to apply knowledge across diverse contexts (Alabi, 2024). When it comes to traditional learning methods where teaching is teacher-centric, and students are passive listeners, students do not participate in any of the activities, and true learning does not happen in that scenario. The scenario is just the opposite in project-based learning outside the classroom.

The next question we asked in the reflective session was

"*How did you find the integration of mushroom farming with other subjects*?"

For a few seconds, none spoke. Later, one participant mentioned that after we insisted on speaking "*Yo hamro laagi ekdumai nayaa experience thiyo (Trans: This* *project was completely new for us), we did research on the economic aspects of mushrooms in Nepal in Social Studies class."* And getting very much excited with an immense smile on the face, another participant spoke *"We have spent approximately a month in this integrated learning process due to which we are very much confident in the topic". Aba jata bata sodhnu vaayo vane paani hami answer dina sakchau (Trans: Even if you ask us questions from any part of the topic, we can confidently answer).* This answer literally left us overwhelmed and felt like our effort was now worthwhile.

From this answer, we believed the students did not limit themselves to the concept of science and technology but also reached out to the nation's economic zone. In fact, they enhanced their research skills from the project. As education approaches modernize under a changed educational paradigm, there is a need to teach students research methods in school to instill scientific research skills. Students learn to think critically, express their opinions, make scientific conclusions, and make reasoned decisions based on laws of science. In project-based learning, students independently research, study the literature on research methods, develop a research plan, predict the expected results, and reach a level where they can evaluate all of this by themselves (Salybekova et al., 2021). Getting engaged in active learning through research on integrated subjects helps students become clear about the various related concepts.

STEAM Pedagogy Enhances Meaningful Learning for Students

During the STEAM project, we observed students working, listened to their conversations, and peered into the classrooms of other subjects in order to determine whether the project was really useful for the students or not. Connecting with the fifth theme, here we have brought some narration of the students and my observation.

Once, in the mushroom farming site, after the class was over and most of the students had gone back, a student (participant) was helping me to clean the area and collect the stuff. We asked him how he was feeling about the STEAM project. One participant answered, "*We had an opportunity to explore so many things this time on our own, like working in the field, collaborative research, presentation, etc., due to which we had a better understanding of the concepts*".

In fact, we had not asked him anything about the lesson's concept, but he used the concept we liked. And, we understood that the project-based and integrated learning approach creates an environment where students can engage, explore, and experiment with the scientific concepts in a meaningful way, leading to sustained learning. As it nurtures critical thinkers, problem solvers, and innovators rather than rote learning, it helps students understand concepts deeply.

We also think it is meaningful to connect this experience with the idea of stimulus and response in the learning process. According to Givi Efgivia et al. (2021), learning is not limited to receiving information, but also it is about an ongoing interaction between a stimulus, something that provokes a reaction or response, which is the learner's observable behavior or action. In this context, the STEAM project's interactive learning environment served as the stimulus. This included engaging activities, thought-provoking questions, group discussions, and hands-on tasks designed to capture students' attention and stimulate their thinking.

When students reacted or responded through their active participation, such as sharing their ideas, asking questions, solving problems, or collaborating with peers, this became their behavioral response to the stimulus. The intensity and quality of social interaction are connected to students' academic success, which also lead to the development of visibility, awareness, and accountability among learners (Boice et al., 2021). This back-and-forth between what the environment offered and how students engaged with it created a dynamic learning experience. It was not passive learning or a one-sided activity; rather, it was an active process in which learners constructed meaning through doing rather than just listening.

We strongly believe that this interaction between stimulus and response is what led to real learning for the students. But here we are not purely presenting the theory of behaviorism by bringing the example of stimulus and response. Rather, we want to argue that stimulus and response can also be ways to construct knowledge. It indicates that when learners are placed in a supportive and engaging environment that encourages exploration and action, they are more likely to be encouraged and their learning becomes sustainable.

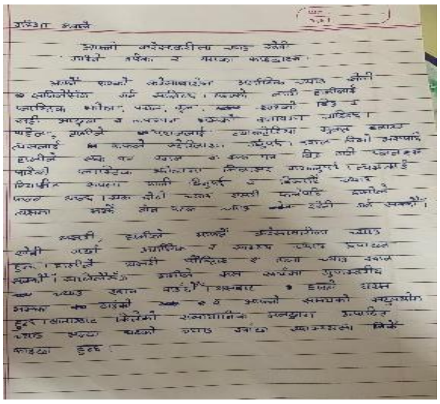
Moreover, in the Nepali language class, where the students had been learning and reflecting on the integration of Mushroom farming with the topic Kareshabaari where students explored the topic in Nepali in context to mushroom farming and its advantages, one of the participants spoke,*"Ekdamai arthapurna sikai bhayo (Trans:It was very meaningful learning), it was a good experience where we integrated Science with Nepali and took advantage of Mushroom farming in our own Kareshabaari". Other students (participant) added "I used to see my mama growing mushrooms traditionally in his own kitchen garden, later my grandmom used to cook and feed us,* *I still remember the taste. It used to be yummy".* While sharing this statement, his face seems nostalgic.

Integration of various subjects is the most beautiful aspect of STEAM. Learning about the kitchen garden (Kareshabaari) in connection with science and technology brought students into the real world from the small pages of the Science and Nepali textbooks. Why don't we claim this as authentic learning, as Omollo et al. (2017) say it occurs when learners actively engage in producing or reproducing knowledge and understanding? In the STEAM project we designed, students not only produced knowledge about the technical aspects of the growth and development of the mushroom as a biological being, but also, they made their learning connected to the economy, environment, kitchen-garden, etc.

In science education, the STEAM approach—which integrates Science, Technology, Engineering, the Arts, and Mathematics—plays a significant role in creating meaningful and engaging learning experiences (Quigley et al., 2019). What we find is that such an idea motivates students not only to internalize scientific concepts but also to experiment with and apply them in creative ways and in real-world scenarios. Our own experience of using the STEAM approach in the classroom has enabled me to claim that STEAM makes learning more interactive, to some extent student-centered, and practical.

Figure 7

Nepali Writing for Kareshabaari Integrated with Mushroom



To engage with a variety of hands-on, interdisciplinary activities, students could think beyond textbook information. They are involved in tasks that require integrating scientific ideas with design, creativity, and problem-solving. Such involvement led them to recognize the relevance of science and technology in day-to-day life. Students enjoyed the learning process through collaboration, brainstorming, and reflection, and developed critical thinking skills.

What we found most effective was how students showed interest in solving real challenges and real-life problems. Instead of just memorizing facts or formulas, they identified real problems, tested solutions, revisited their strategies, and came up with practical solutions. Such learning approaches empowered them to take ownership of the knowledge they constructed.

One day in the classroom, we wanted to check whether the project work supported understanding the concept. For that, we asked the students to write about how the project was meaningful for them. One of the writings was "*I understood the concept, I learned how mushroom grows and what we need to do for this". Others wrote "It gave us an in-depth idea of structure, classification, life-cycle, habitat, and characteristics of mushrooms".* We were glad to read that the students have shared their understanding clearly in their writings.

Like the previous participant, this participant also expressed his clarity on concept *"To observe how mushroom grows and relate that observation with the concept of the lesson and through integration with other subjects have helped us in learning"* With the interdisciplinary integration, two or more disciplines are combined into a specific concept to achieve the learning objectives and helps to answer the fundamental questions through inquiry, innovation, critical thinking (Ozkan & Topsakal, 2021). Now we realize that no real learning happened to us when we were students, as we had no experiential learning. Not every scenario allows me to teach through integration or experience, but when I am able to do so, I feel really proud and overjoyed.

Later, we visited the social studies class as they presented the findings of their research on the mushroom and its economic connections. One of the group members said at last "*We will never forget this project, which allowed us to understand the concept of different subjects together. Mainly, I am impressed to know about the scope of trading and business in relation to mushrooms".* We have seen how hard students have worked on a group presentation. This time, while we were also involved in their learning about economic activities in social studies, we were overwhelmed by their effort in rich discussion, sharing, and presentations. So, they were excited to share *"Mushroom trading and business in a developing country like ours can be very beneficial to uplift the status of citizens".*

The learning environment plays a significant role in learning outcomes. Getting directly involved in the settings had a greater impact on students' learning. The learning environment included all the core elements of meaningful learning: active, collaborative, constructive, authentic, and goal-directed.

In the same social studies class, after the presentation of a group, we asked a question,

"Why do you think the integration of different subjects was meaningful?"

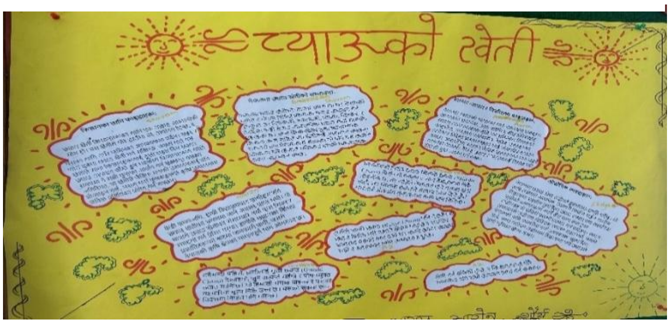
One of the group members said, *"We've got to work in a real learning setting. Eutaa maatra subject maa limited vaeko vae testo hudainathiy (Trans: It would not be possible if our learning was limited only to one particular subject)."*

Another group member added,

> *Going out of the classroom and working in the field was the best part. Haami sabailaai classroom bahira kaam garna ramaailo bhayo (Trans: It was so fun working outside the classroom). We could use our knowledge and experience that we already had.*

Figure 10

Chart paper work on economic activities of Mushroom in Social class



Through the learning settings, they encompass the emotional, cognitive, and motivational dimensions. The settings in school for the STEAM program in Makers-space, an after-school program, or outside the constraints of a single-subject lesson plan or a single concept or discipline appeared to enhance students' overall learning experience, making it deeper and more meaningful (Bertrand & Namukasa, 2020). In traditional settings, meaningful learning is almost impossible as all the basic components required for it are lagging. There are no real-life connections, and memorization occurs without understanding.

The entire activity was meaningful in that students connected the project activities to real–world contexts and, during the learning, developed problem-solving, communication, and confidence skills. They also connected other subjects within the same area, with abundant, integrated teaching and learning activities and an in-depth understanding of the concepts. While preparing the substratum, maintaining temperature and humidity, and observing the cultivation process, students apply knowledge of various aspects of science, such as physics, chemistry, and biology. The problem-solving skill was developed by identifying the cause of contamination. At every step of mushroom cultivation, students developed their own understanding, aligning with STEAM-based learning. Meaningful learning happens when students acquire new knowledge that builds on their pre-existing knowledge and connect it to that knowledge (Sexton, 2025). Meaningful learning occurs when what students are learning relates to their pre-existing knowledge, and they can connect the new knowledge to it.

STEAM Pedagogy Focuses on Process rather than Product

During the final phase of the project, students observed the growth of the mushroom's fruiting body every day, following our mushroom expert's instructions. One of the students spoke, *"I had hoped that we would be successful in growing the mushrooms, but the result is not very exciting,"* and another added, *"I am really disappointed"*. I replied, *"See, we always have to hope for the best result, but I strongly believe that learning is measured by the process, as we all could learn new things that can also be applicable in our real life"*. Based on this statement, we were able to convince ourselves that success is not measured by the product but by the process, as students' real learning happens during the process. Moreover, they had to tackle many problems along the way, such as resource shortages, harsh weather conditions, time management, and financial management. This led to PBL (Problem-based learning), where students learned actively and meaningfully. They were given problems to solve collaboratively, create a metal model for learning, and form self-directed learning habits through practice and reflection. The principle of constructivism positions students as active knowledge seekers and co-creators who organize new relevant experiences into personal mental representations or schema with the help of prior knowledge, which is further reinforced by social theories of learning that postulate the merits of social interaction in cognitive development (Yew & Goh, 2016). We often have misunderstandings in the learning process because we always measure it by the end result rather than the skills we develop along the way. During the process, several types of hindrances arise that make our work difficult. Sometimes we may also not achieve what we actually wanted, which can lead to disappointment and disheartenment.

The sad part of the story is that, due to unavoidable circumstances and unfavorable weather patterns, we were unable to grow mushrooms as expected. We could convince our students that failure is also a part of our learning. During the discussion of our unexpected results; One of the students shared, "*No worries, ma'am! The several steps and processes in STEAM-based learning in the Mushroom project helped to develop several skills despite the failure in the result"*. Other students added, "*We will surely try for the next time, as we have realized where we were lagging*". And one more said, *"We should have taken care of the contamination* *that happened in most of the packets."* They had worked with all their heart since the beginning of the project. Amid all the sad faces, one of the primary researchers (a computer teacher) said, *"We will surely try for better results next time*." After hearing their conversation and statements, we felt they truly respected the process-based learning. Not only did they learn how mushrooms are grown, but also the factors that negatively affect their growth. As Dewey (1938) mentions, learning is a social activity, and failure also exists in society. Thus, we can claim that the experience of failure or partial success helps students to construct knowledge.

Similarly, in the Mushroom Project, even though the final outcome was unsuccessful, students still gained valuable competencies such as scientific inquiry, collaboration, and adaptability. During this process, students can thoughtfully reflect on their process and identify the gap. The journey of learning fosters skill development, regardless of the outcome. The science learning process should be designed to not only deliver content but also broaden students' understanding, nurture critical and scientific thinking, and develop their ability to work systematically and communicate effectively all of which are essential life skills in today's world (Julimah et al., 2020).

When we reflected on my own school experience, learning in those days was often focused more on products than the process. The prime objective was to achieve good grades by performing well in exams, rather than truly understanding what we were learning. We hardly became inquisitive or tried to explore the deeper meaning behind scientific concepts. Instead, we were focused on competing with other students and putting pressure on ourselves to achieve better scores, not by curiosity or a desire for knowledge, but by memorizing the facts and presenting them on the exam papers. This approach really helped me score well, but it did not always equip me with the deeper thinking skills or scientific mindset that education is meant to foster. Yet, the late realization has supported me encourage students to go beyond rote learning and focus on developing meaningful, lasting skills.

A similar opinion was recorded from one of the participants. Participant stated, *"I enjoyed what we did. Our aim to grow mushroom could not be fully successful but I learnt many things while doing it."* Another added *"But I am very sad as we had so many plans to sell it, prepare recipe of it and make profit".* The disappointment was evident in the students' eyes.

Though the mushroom production and selling could not happen, the students engaged in the several process of preparation. There were several activities the students participated in, from which they could learn a lot. Project-based learning not only contribute to the development of employable skills but also enables universities to work in more synergistic way where the curricular, co- curricular and extra-curricular enhance the experience of the learner through a focus on sustainable development (Leal Filho et al., 2016).

The above-mentioned statement emphasizes the multiple values of project-based learning (PBL). Project-based learning is not only a teaching method but also a comprehensive approach that prepares students for the demands of the real world by providing real-life skills such as critical thinking, collaboration, communication, and problem-solving. These are the basic skills people need to survive or make progress in the competitive world. Likewise, the same statement highlights that project-based learning emphasizes the holistic development of the learner. In fact, project-based learning brings curricular, co-curricular, and extra-curricular activities together and integrates them so that meaningful learning is possible in an integrated, not an isolated way.

Looking sadly at the not-so-good production of mushrooms in the mushroom house prepared by the students, one participant said, *"How can this happen? We togetherly worked effortlessly to make this possible".* Another student stabbing on this shoulder, *"Hamile arko choti garda chai ali careful bhaera garnu parcha for better results (Trans: we should be cautious enough when we do it for the next time to get better results)*. He added, *"Let's identify the cause of the poor result".*

To enable students to learn science better, teachers must consistently and systematically emphasize the process of science during instruction. Process-oriented learning provides students with opportunities to self-regulate, learn to communicate, and develop emotional intelligence. Thus, it's high time to shatter product-oriented learning and embrace the limitless potential of process-oriented education. No matter the outcome, we should focus on acquiring knowledge rather than the end result. To improve the students' learning outcome, such as participation, engagement, persistence, and aspiration in STEM and STEM-related fields, STEAM plays a vital role through creativity and design thinking (Bertrand & Namukasa, 2020). The tendency to accept the end result, while ignoring the skills developed during the process, was the harsh reality of the traditional learning process. This tendency makes the students lack confidence and hinders their learning.

Different Types of Learners Increase Their Engagement and Functional Literacy While Practicing Mushroom Farming

We had arranged a field visit to a mushroom farm in Bhaktapur to explore mushroom farming, the types of mushrooms, and their health benefits. Despite unfavorable weather and uncomfortable surroundings, students coped. They had several interactions with the mushroom expert and could witness the equipment used for large-scale production. Meanwhile, one student, after listening and observing the various other products of mushrooms, shared, *"I never knew that mushrooms could be so expensive and beneficial"*.

Reflecting on the student's statement, we think that these days, high school students are unaware of how much mushrooms cost. Actually, they eat mushrooms but do not know their economic value. Students got shocked when we said "*Some mushrooms are really expensive as one kilogram of mushrooms can cost up to 500$*". After listening to my statement, students were stunned and began asking various other questions. Some of them started converting the amount into Nepalese rupees. One participant recalled this and stated, *"Once my father got this mushroom, I had eaten it a few years back"*. Engaging in a STEAM project, they got to know the price of the mushroom, which was a big learning experience for me.

Some of the students even bought the extracted red mushroom packaged in a vessel. We asked, *"Why are you buying this?"* He replied, *"This is for my grandfather who is suffering from high BP". It was interesting to see them getting into the process. One more answered, "This is for my mother, who is a diabetic patient"*. We were glad to see the love and care towards their parents and grandparents.

Figure 13
Students having Keen Observation on Mushroom

Likewise, we once asked the students about their experience of real engagement in the project. One of the students shared, *"We actively participated in the project where the learning happened by engaging in several aspects of learning and mastered basic skills required in everyday life"*. As the students have learned through multiple learning methods utilizing their basic skills, such as budgeting, leading, calculating, asking questions, teamwork, etc., by getting actively engaged in the process, they have developed functional literacy for the present and future.

Students' prior knowledge, their active participation in problem solving and critical thinking play a crucial part in the construction of knowledge (Khan, 2019). During the STEAM project, we observed that students' prior knowledge, active participation, and critical thinking factors were important aspects in shaping their learning journey. As Khan (2019) explains, these elements are crucial to the construction of knowledge, especially within a constructivist learning environment. We noticed some of the students bringing their prior knowledge of mushroom and other species of fungi to relate in mushroom farming. Also, their prior knowledge of designing the place for mushroom was important. Also, they felt valued for developing that knowledge.

Similarly, students actively engaged in the project by planning the mushroom bed, monitoring humidity and temperature, and arranging all the required supplies, which were examples of involvement in real-world problem-solving. Every decision they make, observation they record, and discussion they engage in contributes to learn deeply. They were not just memorizing steps; they were critically analyzing what works, questioning why certain methods succeed or fail, and refining their approach based on evidence. This process reflects the core theme of STEAM education, which emphasizes hands-on inquiry, creativity, and interdisciplinary learning.

Moreover, such a project enables meaningful collaboration and encourages students to communicate their findings, document their processes, and reflect on their outcomes. These experiences help them move from passive recipients of knowledge to active constructors of understanding, where learning becomes both relevant and transformative. In this way, the mushroom farming project becomes more than just a science activity, it becomes a platform for building life skills, nurturing environmental awareness, and fostering a deeper understanding.

Using the STEAM approach, educators can cater to multiple learning methods, thereby increasing student engagement and functional literacy. This further helps learners prepare to deal with the complexities of the future in all ways. STEAM is the answer to develop all the essential functional and tactile skills and to help excel further to become the one our country needs, as mentioned by Long II & Davis (2017). We have seen people neglect the functional skills that are pivotal to dealing with the challenges and demands of daily life, from managing emotions to making informed decisions.

We have a student in the class who is very active doing work physically but always reluctant to read and write. We asked him about his experience in the STEAM project, as we noticed different levels of energy throughout the process. He said, *"I get bored when I have to do tasks like reading and writing, so this time, as there was a blend of activities, I learned from what I saw and what I did rather than reading and writing."* Similarly, another student said, *"She was not good at writing answers, but she observed and participated in activities with curiosity and enthusiasm*." To keep her motivated, I said, *"I am really proud of you being actively engaged in the process,"* and listened as she smiled. These narrations are strong evidence that different types of learners are addressed in the STEAM project. Students learn many things with projects because they enjoy learning more, can learn through experience, and have a better understanding of the subjects. While engaged in their learning tasks, students are actively involved at every step of the learning process, unlike classroom learning, which can bore students and make it easy to forget the material they have studied (Desrani et al., 2024). Due to this rigid, uninspiring environment, with limited interaction with the real world, we could not focus on skill-based learning as students. Teachers never had an idea about the diverse learning capacities of the students.

While exploring ideas for their computer science-based project in "Mushroom farming" during the learning of designing a website, one of the students mentioned "*The more we got involved in the project, the more we developed the curiosity*". Two of the students who are very much into Information and Communication Technology; one of them shared, *"We love making websites on different topics and doing IT-related projects. My father is an IT engineer, and I get inspired by him."* Meanwhile, others also added, *"Additionally, working on website designing for mushroom farming helped to develop our knowledge in two different subjects."* The project-based learning, where students are given the opportunity to take ownership, reflects an increased level of curiosity and motivation for their projects. When students are allowed to explore, ask questions, and define challenges they wish to tackle, learning becomes more fun than an obligation. Students are involved in active learning, where their curiosity is awakened, they set self-challenges, and they meet while solving problems and working on a project (Liu et al., 2024). While recalling our school days, where active learning was completely missing, as there was a lecture-based teaching method, rote call memorization, and we missed the opportunity to analyze or synthesize, we were completely lagging in functional literacy and the active learning process.

Project-Based Learning in STEAM Develops Students' Learning Aptitude and Competency through Collaboration

During the verbal sharing of the project, as it was about to end, key participants shared their experiences in response to the questions we developed. Participants emphasized what they learned and the aspects that need improvement for the future. One of my questions was *"How has this integrated method (STEAM) of learning mushroom helped you understand the concepts?"* Participant shared "*As there were varieties of aspects of the project, such as writing, experimenting, observing, and presenting, to engage in the project and have a deeper understanding of the concepts".* Another added, *"The best part was integration with other subjects through the STEAM approach".* Now, not only the co-researchers but also our participants (students) are familiar with the word "STEAM". Project-based learning enhances both conceptual understanding and practical skills by applying theoretical knowledge in real-world contexts, thereby strengthening learning outcomes. This helps to develop a sense of ownership in their learning. Also, students are more curious, excited, and enthusiastic about seeing their own ideas come to life. While working on projects, students often encounter challenges as they need to think critically to retain their knowledge. The project-based learning focuses on student-centered, team-based problem-solving, with an emphasis on real-world problems. (Hsiao et al., 2022). When it comes to working on the project, we have seen a next level of enthusiasm among the students. Students really enjoy the process and indulge in the activity in a fun way, and we feel this makes learning in a real sense.

Learning Science through a STEAM project develops cognitive skills such as listening, problem-solving, and decision-making, involves students in practical activities, and is directed toward real-world situations (Muzaini et al., 2024). This approach makes learning fun, meaningful, and applicable, making it a potential learning model that can be widely adopted in education.

During a reflection session given to a group of students about the entire project and their learning, a girl student shared her opinion: *"I had never found science and its concepts easy in the past, but now I have started to find it interesting and easy both." Another one has also mentioned in a similar way. Using one topic we* *covered, other topics of other subjects together and had a better learning and in-depth understanding".* The interest in learning and the ability to learn do not improve overnight. It is a slow process. If the STEAM project helps students develop their learning interest in any subject, that is a big success for the teacher and the student.

Chistyakov et al. (2023) state that authentic and valuable learning is possible through projects, as students acquire knowledge independently. The project-based learning encourages students to take ownership of the knowledge they have constructed. Instead of passively receiving information, students eagerly engage with real-world tasks, excavate the problems, and independently or collaboratively seek solutions. We believe this process is meaningful not only for deepening their understanding but also for helping them develop critical skills such as inquiry, reflection, and self-direction, which makes the knowledge gained more relevant, lasting, and personally meaningful.

Before we began our research work, we sat together with all the key participants and brief them about the STEAM and integrated learning. We also elaborated on how we, teachers from all five subjects, will collaborate, connecting a topic across all disciplines. And after the completion of the project, one of the participants, when we asked some questions about their knowledge of STEAM, *said, "I got to know a lot about STEAM after doing this mushroom, and it has helped me in learning Science and other subjects as well."* They also had researched it, so they were so glad to be a part of this research and learning, and during this, another mentioned, *"I used to hear about STEM and STEAM a lot, but now knowing about it in detail and being a part of it makes me feel very fortunate".* They said in unison, *"Thank you, teachers, for this opportunity*." STEAM learning projects can be a powerful tool for advancing STEAM education and a necessary evolution in preparing learners for the challenges of the future. It further enhances the ability to apply concepts innovatively and persistently. Project-based learning is designed with an integrated learning approach in which students are provided with challenges, analyze using scientific literacy skills, select strategies, and teachers measure and assess learning outcomes (Chistyakov et al., 2023). In our school days, there was compartmentalization of disciplines where learning aptitude was barely seen. Moreover, we were not privileged enough to get opportunities, as we could not practically implement our understanding. Despite developing several projects, we had no clue of the concepts and skills that were involved in it.

Educating young people with transdisciplinary abilities supports transformative learning experiences (Taylor, 2019). So is the case with STEAM pedagogy, which promotes a transdisciplinary approach. The mushroom project would not have been such interesting for the students if it were not connected with multiple disciplines.

As part of the STEAM research, where students were meant to prepare several STEAM models integrating several aspects of STEAM subjects for the STEAM project, one of the students shared, *"Learning the same aspect in different subjects with different objectives by joint effort of all teachers helped in the clarity of the concept and the objectives"*. The student who developed an aircraft said, *"Though this aircraft requires more knowledge from physics, our art teacher guided me to develop its structure and provided me with the required materials"*. Teachers from different disciplines collaborated and created opportunities for students to see how concepts connect across subjects. The STEAM approach allows students to develop a deeper understanding and view problems from multiple perspectives, improving their problem-solving skills. Working together in a group not only helped them collaborate but also enabled them to integrate diverse skills and perspectives for success. STEAM can be a vital tool for character development, especially through collaboration and creativity, which play a key role in holistic development (Mustoip et al., 2024). It focuses on the importance of collaboration among students and across subjects, enabling students to be more creative in solving problems and to adopt a critical perspective on different realities and facts.

Figure 16

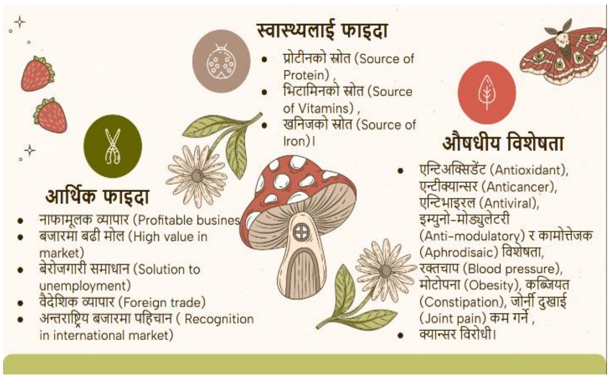
Aircraft Developed by Students as STEAM Project

In past years, when concepts were taught with no connections across disciplines, it was challenging for students to develop them. Collaboration makes learning more effective, not only for students but also for teachers, as multiple ideas can be discussed to achieve the common goal.

While visiting the Kareshabaari (Kitchen garden), seeing the possibility of Mushroom farming in their Kareshabaari (Kitchen garden), discussing the possibility as a STEAM approach helped in collaborative learning, as through STEAM, students are encouraged to work together in projects that require input from multiple areas, which allowed us to connect our diverse strengths and perspectives. Professionals from different fields work together to solve real challenges, thereby fully strengthening group dynamics. Maker culture, as one of the approaches of STEAM education, has the potential to promote collaborative learning in education in both formal and non-formal settings, providing practical situations in which students are protagonists in the construction of their own knowledge and the teacher as the mediator of the process (Rodrigues et al., 2023). In discipline-based learning, we had no opportunity to collaborate on ideas or groups. This made us detach from the real world, from everyday experiences, or practical application.

Figure 19

Poster presentation on importance of Mushroom in Nepali class



When they were asked to brainstorm on the questions related to Kareshabaari for their prior knowledge in Nepali language, students discussed, shared and came to points that could enhance how mushroom farming is even possible in our own kitchen garden. After the discussion, they also shared, *"As mushroom cultivation is even possible in a small area, we can manage to grow even in our kitchen garden using the learned technicalities".* Some students prefer learning in a group rather than in isolation. In a group, they do not feel like they do in the conventional classroom, where they are forced to read and write. "Students can work individually or in groups during the project-based learning process" (Chistyakov et al., 2023). We have lately realized that peer learning or group learning, students share their ideas, information, engage in discussion, and solve the problem through teamwork. It also fosters a sense of accountability and motivation as students are more committed when working in a group.

Learning through projects helped students by placing them at the center, addressing the lack of creativity that exists in traditional curricula, while teaching staff plays an advisory role, guiding students to take an active and autonomous role in their learning process (García-Llamas et al., 2025). In individual learning, struggling students often feel low and less important in the class because they cannot compete with high achievers. But in teamwork, everyone feels equally important. They do not have to be left alone. This is also one of the reasons that students like the project-based learning approach.

STEAM Pedagogy Can Intrinsically Motivate Students to Learning

Figure 22

Discussion on Topic Kareshabaari in Integration with Mushroom

While observing the students working to their best on the project, integrating the Nepali language into the topic Kareshabaari, we were surprised and overwhelmed to see them deeply engaged in discussion and sharing. My co-researcher (Nepali language teacher) also said *"Maile sochekai thyena esto sincerely kaam garchan vanera (Trans:I had never expected they would work this sincerely), kasto majjale le lekheka chan (Trans: They have portrayed so well)."* One more participant mentioned, *"I developed a sense of responsibility through this project".* Integrating arts in STEM has helped students to perceive themselves as capable of coping with unknown situations and problems instead of becoming stressed and experiencing anxiety (Conradty et al., 2020). Students can have a profound impact on self-motivation, self-perception, and learning, as the flexibility and freedom can make learning more enjoyable, allowing students to see learning as a playful yet meaningful endeavor. The relevance or connection fosters motivation for autonomy, regardless of the outcome. As students take responsibility for their own learning, their intrinsic desire to learn boosts their learning. Our learning happened with no integration, which was a traditional method as rigid, and there was no sense of ownership, only targeted for better grades (extrinsic motivation), which we feel did not last longer in terms of retaining the knowledge and understanding.

While excitedly and enthusiastically working in the field, we collectively said to the students, *"We are proud of you all, your hard work will surely payoff".* The students seemed to be happy with my encouraging words. One Participant shared, *"They could work on their interest beyond the walls of their classroom, where they had fun learning and explored the concepts".* Learning in the classroom provides a structured environment, while learning beyond the classroom encourages curiosity, creativity, and practical application. This exploration let students become more motivated, well-rounded, and prepared to face future challenges. For the diverse learning experiences, learning needs to be connected to the learner's personal and social world, and classroom learning constitutes only one facet of the whole learning experience (Chik, 2018). In traditional learning settings, no such things as field trips, project work, hands-on activity exist where students get the opportunity to explore beyond the four walls of the classroom. All learning happens in class through rote memorization and knowledge transfer.

Using STEAM projects in learning students' scientific self-efficacy influences persistence in science and career choices, students assign the task itself, the future utility the task may have for the student, and the pleasure experienced in performing it (García-Llamas, 2025). All the mentioned traits are components of intrinsic motivation. Motivation is crucial for students to feel confident and believe their effort will achieve meaningful outcomes. The motto is to make students competent at the professional, personal, and social levels, understand their motivation towards innovative methodologies, and determine the degree of satisfaction.

While having a conversation in an interview with one of the participants, we asked, *"Is this entire mushroom project worth doing for your learning?"* One of the participants said, *"I want to try other projects like this, let's do the same way for other topics, and I am sure everyone will have actual learning"*. Another added, *"Ma'am, we will guide the next batch of students on this project so that the school will not need expert help"*. She further added, *"Let's do a similar project for the topic simple machine"*. When students are motivated from deep within, they start exploring various ideas. They might also consider engaging in the other projects. STEAM modules foster students' creativity by encouraging them to imagine, explore, experiment, test, manipulate, and speculate. Intrinsic motivation appears to be a relatively homogeneous construct within educational psychology, as engaging in an activity for its own sake because it is inherently interesting or enjoyable, is a powerful force shaping human behavior (Howard, 2020). As a student, when I think of my past days understanding a concept, receiving praise from teachers or parents used to boost my confidence, while failure,

Figure 25

A student happily posing after mushroom cultivation

lack of support led to discouragement. Thus, creating a supportive learning environment for meaningful learning seems crucial.

We were very glad to hear from students while working in the field, and saying *"Aba ma afai afno mushroom farm kholchu (trans: I will start my own mushroom farming),* and another added *"Let's do it in partnership".* Now the previous one replied *"I will ask my dad for the space as we have enough space in our farm house at Lele".* They seem very excited as they were confident enough about the procedure. The freedom given to the students allows them to experiment, create, observe, and feel a deeper connection to the material. This fosters genuine interest and love for learning, which is the key to intrinsic motivation. This further caters to a wide range of learning styles, and this type of environment naturally cultivates the motivation from within.

Creativity might promote intrinsic motivation, as the connection between motivation and dopamine-related activities has been found at the neuronal level, a mechanism that is thought to underlie human creativity (Conradty et al., 2020). This neurological connection suggests that when individuals engage in creative work, it can stimulate pleasure and reward pathways, enhancing their intrinsic motivation to learn and explore. In this way, creativity doesn't just produce new ideas but also fuels a deeper, more self-motivated engagement in the learning process.

During our times, there was mainly the extrinsic motivation that would exist, where we just focused on outcomes or rewards rather than the learning, which happened to be short-term. We used to rote call for getting better grades, which didn't really help in a real sense of learning.

In the context of economic studies, while studying business and trade, they learned about the economic importance of mushrooms, specifically in Nepal. They conducted research, discussed, and shared possible economic activities that Mushroom farming can create. One participant stated, *"I will do my own business using this learning as this business does not require a high initial investment cost and is very favorable in our country*". Another replied "*Surely! Using this we can help to uplift the economic status of our country".* My coresearcher (Social studies teacher) smiled and said, *"Please provide me a certain share of your business and she laughed, "hahahaha,"* and the student further replied, *"Bhailcha ni ma'am" (Trans: Ok, ma'am).* Getting outside the classroom and learning several skills through STEAM projects motivated students to improve their lives. Their enthusiasm was vividly seen, and they were extremely motivated to work together in real life. As the 21st century is more focused on skill-based learning, the entire project helped them excel in several skills required for the present and future. We never expected the students to participate with such dedication and motivation. The purpose of education is to guide students to integrate interdisciplinary knowledge, to trigger their interest in STEAM learning, and to develop their employability through STEAM (Hsiao & Su, 2021). Reflecting on our experience, there was no motivation; we were forced to get better marks or grades because our learning was solely based on the report card. There were no such things as skills or real-life learning. As the scenario has changed, the students in this situation are really fortunate, as they are getting all the opportunities and exposure that play a remarkable role in shaping their future.

STEAM education is a teaching approach that fosters learners' interest in STEAM courses by developing their individual capabilities of expression, innovation, and aesthetic perception, with innovation being most important (Hsiao & Cu, 2021). It's high time for all the countries to emphasize interdisciplinary learning and application, and adopt education for sustainability, and to initiate curiosity among the learners. For meaningful learning, students should be intrinsically motivated, as their cognitive load also decreases. Through integrated learning, students develop the ability to express themselves, observe, cooperate, and communicate.

Theoretical Connection

After presenting the nexus among the themes and participants' experiences, we would love to connect it to the theoretical aspects of the research. As mentioned many times above, we are connecting the thematic discussions with the critical lens of learning and constructivism.

Enhancement of critical thinking skills is one of the expected positive outcomes of the STEAM approach to learning and teaching. Ennis (1985) explains the positive aspect of critical thinking as reflective thinking about what is good to believe and what is better not to believe. During mushroom farming activities, we observed students gradually becoming more critical of their own work and understanding. In reflective sessions, they inquired about their own previous belief that science was always difficult. Critical thinking, when nurtured in this way, contributes to a more effective and meaningful science classroom (Demir, 2015). Also, they were critical of the current project, questioning whether mushroom farming was really for learning science or just a project for fun. Such an inquiry-based approach and self-driven participation in discussion enhanced critical thinking skills.

STEAM is an integrated, interdisciplinary approach that encourages students to think broadly and critically about real-world problems (Pant et al., 2020). Students developed a deeper understanding and a creative way of learning science through inquiry, reflection, and active engagement in hands-on activities. Thus, STEAM is not only well-suited for promoting content knowledge but also for fostering thoughtful, reflective, and critical learning.

The basic foundation of constructivism is that knowledge is constructed rather than transferred or inherited. Similarly, knowledge construction is a social process (Dewey, 1938). This means that knowledge cannot be constructed in isolation; a complete social process is required to produce it. Dewey (1938) further states that real education is gained through experience. Here, the social process and experience are given importance for a student's real learning.

Through the narrations we collected from the reflective session with the students, we realized the students could construct the knowledge because they got the opportunity to work actively in the real field. Khan (2019) asserts that problem-solving experiences are keys to constructing knowledge, as they actively engage learners in thinking, analyzing, and applying what they know to real or meaningful situations. Rather than simply collecting facts, students develop a deeper understanding when they are challenged to find solutions, make decisions, and reflect on outcomes. This process encourages critical thinking and learning by doing, which not only reinforces existing knowledge but also helps in forming new concepts through direct experience

We could say that our students were not only involved in solving a real problem but also experienced success and failure while trying to build a mushroom farm, which led to their construction of knowledge. Here, we would say that it’s not only our research that is backed by constructivism, but also that the same theory is empirically supported by what we found in the project. The same idea of constructivism is well described in Driver et al. (1994) argument: learners construct meaning and knowledge from their experiences, and learning is a dynamic, social process. From this point of view, learning is not a passive act but a dynamic, evolving process shaped by the learner's interactions with their environment, peers, and prior understanding. They argue that knowledge is built through active involvement, in which learners interpret new information using what they already know, often restructuring their ideas in the process. Furthermore, they value the social interaction in learning, explaining that discussions, collaboration, and shared problem-solving play a vital role in how individuals make sense of the world around them. This means that learning is possible in that place where students can question, explore, and construct knowledge collaboratively, rather than being limited to memorization or one-way instruction.

We believe that our students constructed knowledge not only from the technical aspects and the act of mushroom cultivation, but also from socialization, team building, and connecting the project to art, mathematics, and economics. Finding the one concept connected with several subjects was really interesting and meaningful for them. Similarly, the constructivist approach values prior knowledge and adds to experiences to create a better understanding. Based on our observations and students' narration, we can say they constructed knowledge from their prior knowledge and the experiences they gained from the project. Andersson's (1990) argument supports a constructivist approach, as he states that scientifically solving the problems deepens the scientific concepts.

This idea speaks in favor of the constructivist approach by stating that when students engage in problem solving, they not only apply what they already know but also, they try to deepen their understanding of scientific concepts. Learners are encouraged to think critically and connect the dots between theory and practice through exploration, analysis, and reflection. Likewise, learners construct knowledge through hands-on activities.

As students solved real problems while working on the mushroom farm, they found the concept clear enough to understand. Also, what we found is that every student came up with at least some idea from the project or built some opinion on the project. Glasersfeld (1995) says that each individual construct unique knowledge in the mind. It advocates that learning is obvious through constructivism. This statement rejects the idea of transferring knowledge from teacher to students. Rather, it strongly argues that knowledge is constructed in each individual's mind. According to his view, learning is a subjective process that varies person to person. Each individual interprets the prior information in a unique way and develops their own understanding. This means each learner brings a unique style of learning process.

Chapter Summary

This chapter is about engaging students in meaningful learning of science by connecting scientific concepts with real-world problems and integrating them with other disciplines. Students got actively involved in hands-on projects, collaborative tasks, and problem-solving activities. Classroom observation and students' reflection revealed that integrated teaching and learning activities enhance students' curiosity and conceptual understanding.

CHAPTER V
INTEGRATION OF ART AND CREATIVITY IN SCIENCE CLASSROOM

This chapter presents how art and creativity were integrated in the science classroom through the STEAM project. Like the chapter IV, this chapter also analyzes the information collected during research. I developed five different themes to address the second research question, “How does STEAM pedagogy integrate art and creativity in the science classroom? At the end the thematic discussion has been connected with relevant theory.

Artistic Expressions and Hands-on Creation Encourage Students to Explore Scientific Concepts

The first theme is about how artistic expressions can encourage students to explore scientific concepts. Here, we are starting with the direct observation, in order to find out how art and creation are being integrated in the STEAM project, we visited the art room in the art (one of the skills) class of the students. When we got involved together and observed, we noticed students were so much into their tasks where they were building “Mushroom house” representing their structure and life cycle. They were having discussions, collaboration and expression of their understanding through arts. Meanwhile the participant shares as “*My scientific concepts on mushroom is well enhanced by using art and crafts*”. So, we asked them “*Do you all enjoy doing this?*” Other students replied “*I have got passion for arts and as for now I realized that we can bring art into everything”.* This statement from the participant was very evident as she explored and experienced several concepts on Mushroom through art where she witnessed and encountered her learning. Through various forms of arts as drawing, model making, painting, students expressed and shared their understanding aesthetically. They vividly could blend science and art together which was very mesmerizing.

Once art is integrated into pedagogy, the learning experience is expected to be more engaging, meaningful, and effective than the traditional, lecture-based methods of teaching (Gadsden, 2008). Traditional approaches usually depend on rote memorization, standardized testing, and passive receipt of information, which can limit students’ ability to connect with the content on a deeper, more individual level. In contrast, the integration of art into teaching activities changes learning into an active, creative, and student-centered process. Art encourages students to explore concepts through multiple sensory and expressive modalities. There are different forms of art which learner with multiple intelligence can incorporate in their learning style. This is not only to enhance retention and comprehension but also to develop critical thinking, imagination, and personal interpretation.

Gadsden (2008) also emphasizes that art-based pedagogy can expand the scope of learning. Arts encourage creativity, critical perspective, inquiry, collaboration, and reflective practice. Students develop the sense of ownership in the learning process if they are provided with the opportunity to create, perform, or visualize their understanding,

Stivaktakis (2018) state that the integration of art into scientific learning is not only beneficial but equally required for catering to the diverse learning styles and multiple intelligences present in any classroom. Art offers varieties of activities to understand complicated scientific concepts by engaging kinesthetic, auditory, and visual learners in effective ways. For example, kinesthetic learners take advantage from hands-on activities such as modeling or dramatization of scientific processes, while auditory learners might find the concept easier to understand through music, storytelling, or rhythmic recitation of scientific facts. Visual learners, on the other hand, can deepen their understanding through illustrations, diagrams, or visual metaphors that translate abstract concepts into concrete representations. Beyond these modalities, art fosters the development of multiple intelligences—such as spatial, bodily-kinesthetic, musical, and interpersonal intelligences—by creating avenues for exploration, expression, and creative thinking. In scientific learning, this not only supports knowledge retention but also cultivates curiosity, problem-solving skills, and emotional engagement with the content, ultimately making science more accessible, inclusive, and meaningful for all students.

Gadsden (2008) has mentioned that within the past 20 years, the arts have gained increasing prominence in educational discourses as well as public arenas. This growing recognition of integration of art in education highlights a broader shift in how art is understood not only as a form of aesthetic expression but as a major component of holistic development and interdisciplinary learning. In education, this approach reflects a deeper understanding of how the arts contribute to cognitive, emotional, and social growth. Art is no longer viewed as an isolated or supplementary subject but it is being integrated into core academic areas, including science and technology, mathematics, and language, as a way to promote creativity, critical thinking, and students' active engagement. The increasing incorporation of artistic methods and perspectives into curriculum design, teaching strategies, and assessment models shows that educators and policymakers are acknowledging the transformative potential of the arts. This evolving stance highlights that art not only enriches learning experiences but also empowers diverse learners to access, process, and communicate knowledge in more meaningful and personalized ways.

We remember one of the participants saying that "*Art isn't about perfection, it's about exploration*". During artistic engagement we dive deep into the creativity and let our mind wander in search of exploring something new.

While we assigned students to do group chart paperwork where they had to research, explore, discuss and express their ideas through visual arts in art room, they seem to be happier than having the usual lecture-based class. During our discussion, one student told me, "*I found learning science easy when we combined art with science.*" And then another student replied "*This way of learning makes us to retain knowledge for longer period without getting bored*".

Figure 28

Visual art of a Basidiocarp of a Mushroom

Our co- researcher (Art teacher) says "*I always integrate other subjects in my class for art work and this time I planned for Mushroom house which is also a new concept to me but I never thought students would come out with this incredible work".* We were so proud to see students passionately working, discussing among themselves and giving their best. The fulfillment could be witnessed through their face. Usually, students find science and technology as very dry and difficult subject. We observed the students' expressions that they were finding the study of science and technology interesting and easy when it was integrated with art. To understand the concept of science became easy when they got to play with the art materials. One of the possible reasons for the students to

Figure 31

Developing a mushroom house in art and craft class

find the integration of art and science interesting is that the different kind of learners can learn in their own way.

Art should be used to make scientific data more appealing and comprehensible as ordinary people can engage with intellectually challenging knowledge of science where knowledge is expressed in creative and artistic ways (Do, 2023). This statement argues that we can make the scientific fact and data more appealing and comprehensible by expressing then in artistic form, as it enables ordinary people to engage with the often intellectually challenging knowledge of science when that knowledge is expressed in creative and artistic ways. Scientific information, especially when presented through traditional, data-heavy formats such as graphs, equations, or dense texts, can be inaccessible or intimidating to the general public. However, by translating this information into visual art, music, storytelling, theater, or other creative mediums, complex ideas become more relatable, memorable, and emotionally resonant.

Artistic representations can humanize scientific issues, highlight their relevance to everyday life, and foster curiosity and critical reflection. For instance, a sculpture representing climate change or a painting inspired by microbial life can communicate scientific themes more intuitively and provoke dialogue beyond academic circles. This approach not only democratizes science but also bridges the gap between scientific communities and the public, making science communication more inclusive and impactful. Furthermore, when learners and audiences are emotionally engaged through art, they are more likely to internalize concepts, ask questions, and develop a sense of personal connection to the subject matter. Thus, the integration of art into science education and communication holds great potential to enhance understanding, broaden access, and inspire both intellectual and emotional investment in scientific issues.

Being myself a science student, I never expected that science learning would be so much fun. We remember our days of school when we had to make some diagrams as science homework. But, we did nothing else except for using the pencil and paper to draw the different system of human biology. Now we can see my

Figure 34
Mushroom house built by skill (art) students

students enthusiastically into connecting art and science to learn.

Somewhere we find the narrow interpretation of the scope of art as it is only to make something aesthetic or beautiful form the outside. The inclusion of the arts has often been considered as merely an approach to improve the aesthetics of an artifact/product' (Liu et al., 2021). However, this limited perception overlooks the deeper pedagogical value that art can bring to scientific learning.

While enhancing the visual or sensory appeal of a product may be one outcome, the integration of art in science education goes far beyond aesthetic. Also, it serves as a powerful tool for inquiry, interpretation, and conceptual understanding. In scientific learning, art can foster imagination, support visualization of abstract or microscopic phenomena, and encourage learners to think metaphorically and creatively about complex ideas. Through drawing, modeling, storytelling, music, or performance, students can represent and communicate scientific concepts in ways that are personally meaningful and intellectually engaging. This approach not only nurtures creativity but also helps students develop critical thinking skills, make interdisciplinary connections, and express their understanding in diverse formats.

By moving beyond the surface-level role of art as decoration, educators can embrace its full potential as a cognitive and communicative bridge that deepens scientific understanding and engagement, particularly for learners who may not connect with conventional methods. Thus, incorporating the arts meaningfully in science learning reshapes the learning experiences making it more inclusive, exploratory, and transformative.

When students were actively engaged in visual art work, we found them coming out of their own creative ideas. Meanwhile one participant shared on "*Artistic expression helped us to understand the topic so well*". Similarly, another student expressed his happiness while working in group, he said*, "Guys, we are becoming creative students finding out new ways of representing mushroom and its life cycle".* After eventually noticing for long time what we noticed was, the art teacher works not only hard but also creatively and joyfully with the students. One more important thing here is the feeling of art teacher that she is also contributing to the mainstreaming subject. The orthodox trend is that art is considered as an extracurricular subject but not as the main discipline of study. We realized that the STEAM project is supporting to enhance the significance of art in learning of any subject.

For the model of STEAM, education to be truly successful, it must be embedded within a school culture that not only acknowledges the rigor and discipline inherent in the arts but also actively fosters creativity, imagination, and innovation across all subject areas (Doniger, 2010). This statement sounds highlighting on shifting the perception of the arts from just a supplementary or decorative technique to recognizing them as essential, rigorous disciplines which can contribute equally to the development of critical thinking, problem-solving, and collaborative skills. As the arts are positioned as a core component of STEAM, students are encouraged to approach scientific and technical problems through creative perspectives, often leading to more holistic and innovative solutions. Artistic processes such as design thinking, visual representation, storytelling, and performance allow learners to express and experiment with scientific ideas in diverse ways that traditional methods may not support.

Additionally, the integration of art in STEAM recognizes the diverse skills and learning styles of students, making education more open to different ways of knowing and understanding the world. Integration of art in different subjects enables learners to connect analytical and intuitive thinking, encourages risk-taking and exploration, and helps them build empathy by engaging with real-world challenges in human-centered ways. Schools that equally value the arts as the sciences can create an interdisciplinary environment where students do not just collect information but actively participate in knowledge construction, come up with creative idea, and understand the value of original thinking. So, for STEAM education in order to achieve the goal of preparing students with the skills needed for the 21st century, art must be well integrated and recognized as a mainstream subject like other subjects. This integrated approach truly invests in future human resources with visionary thinkers and humanistic innovators.

During the STEAM project, we observed students being helped by the integration of art to conceptualize scientific concepts and the artistic representations at the same time. Artistic expressions have helped them to have a colorful way to deepen the understanding as scientific learning becomes more engaging and impactful with arts. As taking STEM as separate disciplines without connecting it with arts, it used to be very dry and difficult and students seem to be detached from the STEM subjects. We believe art has played a vital role in motivating students to pursue their carrier in

STEM subjects. The arts can transform STEM teaching and learning by highlighting creativity, innovation and problem solving as core aspect (Stewart et al., 2019).

In traditional education system, STEM education also has often emphasized only on technical proficiency, logical reasoning, and factual knowledge, sometimes at the expense of creativity and imagination. But, the inclusion of the arts redefines the scope of learning by encouraging students to think beyond limited ways and to explore multiple perspectives and possibilities. Through artistic practices such as design and visual expressions students get to engage in processes that reflect scientific inquiry, asking questions, experimenting, interpreting results and finding the best solutions. This changed approach in learning enables students not only to master concept but also to approach problems with original idea of solution, flexibility, and empathy. We believe that artistic engagement develops the skills required for 21st-century, such as collaboration, communication, and emotional intelligence, which are helpful to solve real life problems. Similarly, the concept of STEAM in which art is equally valued as other subject, supports for deeper emotional connections with the meaningful learning.

Going back to the previous days, myself as a science student during my college studies, it used to be very difficult to grasp certain concepts which were abstract and non- linear thinking. Learning science requires putting aside your own belief, evaluating the quality and meaning of evidence before you and staying objective.

Figure 37
Students working for visual arts for life cycle of Mushroom

While preparing for their chart paper presentations on structure of Mushroom, the students seemed to be busy in multiple tasks. Some were busy cutting, pasting, gathering the information, and performing many other tasks. While doing their job a student mentioned "*The project also helped us to develop our fine motor skills like cutting, attaching, pasting, kneading clay, etc.*" She further added, "*We are just passive listeners in the lecture-based class, and we feel so sleepy, and I expect most of our classes are based on the activities where we can remain engaged actively.* Several motor tasks are related to cognitive abilities as attention, executive function, working memory and cognitive flexibility differently and also helpful in physical, mental and emotional development (Frikha & Alharbi, 2023). As most of the children are negatively affected by excessive use of technology, as it reduces their motor competency, art-based learning is found to be an effective method for increasing focus and attention. This problem was mainly seen during COVID- 19 times where children were mainly into devices for learning, socializing, communicating, etc.

Integrating Arts and Creativity in Science Classroom Enriches Students' Critical Thinking Skills

After discussing the value of arts in learning, this particular theme is focused on the creativity and critical thinking. Actually, our research questions do not only make me look into the integration of art and creativity but also it instructs me to see how students are developing critical thinking skills.

Initially, while getting students involved into the concept of mushroom farming, we grouped the students and then gave them separate topics to explore and find their own creativity to work on the given topic. The topics were related to the different scientific concepts of mushroom. They took some time to discuss among their group members, gathered some more information or contents for their work, expressed through arts and power point presentations and later shared among all.

After accomplishing their work when we asked them about their experiences. One of the participants shared in their reflection as "*arts helped us to uncover the complex or abstract scientific concepts which makes easier to comprehend and creating such tangible representations helps to retain the understanding*". Similarly, another participant had shared *"When same concepts are introduced by teachers through lecture based it would blow out of our mind*".

As teaching science is no longer in isolation, nut is interwoven with other subjects which makes the abstract scientific concepts more tangible. Thus, integration helps to tackle real world challenges where students have to think critically and work creatively. Costantito et al. (2014) mentioned that "Artistic images and models can provide us easier access to elusive words which usually remains hidden or ignored". We still can reminisce how STEM subjects used to be dry and stressful with no fun as there was no "A" component. It used to be very difficult to retain the concepts as the learning was very disengaging. One of the reasons why we felt disconnected and disengaging as we were not prepared for future rather my outcomes were measured in literacy and numeracy.

While we were taking feedback from the students after a class, one girl said, "*the project was fine, it gave us fun, but some students were only having fun, they hardly learnt. The project made us creative, but this type of method might not be useful for everyone."* When we reflected on the argument of that particular girl, we realized she was critically appreciating the STEAM approach in learning. In fact, it was a great achievement for me that my project was developing critical thinking inside the young mind of my student. As we remember we do not find myself with critical thinking when we were in school days. We hardly used to criticize teachers' teaching style. In fact, we used to think teachers' every action and words would be correct.

Now we realize, STEAM approach does not only make the students creative but also it enhances the critical thinking skills. "Scientific ideas and works of art help us transform our perception of reality" (Stivaktakis, 2018). The statement sounds emphasizing the importance of arts in transforming the perception of the students. Acknowledging the argument, we would say that the transformation of the perception sometimes goes with the critical thinking. Instead of fully supporting the STEAM project, some students criticized it with logic, which is a big example of the development of critical thinking in the students. Even we also believe that same method cannot be useful for all the students which could be put down in differentiated learning process as for everyone same learning method may not be useful. We have started using differentiated learning method for the students who get to learn through their own methods.

While we asked students to write a reflection on the procedure of the mushroom farming and its integration with various other subjects, we realized how students enjoyed it and had meaningful learning. They have critically analyzed and reflected their learning in so many wonderful ways. One of the participants has written "*Integrated method helped us to get the answer to our questions which could not be solved by one subject alone*". Our co- researcher (Computer teacher) was also very glad and said, "*Reading at their reflection shows that they had a keen observation and had collaborative learning through the integrated learning method.*". As the learning process is a blend of various integrated plans and approach, students got an opportunity to be involved in planning and implementation where they could eventually develop all the skills required for 21st century. The integration of real-world scenario into the curriculum fosters the well – rounding understanding of the world. And the interconnectedness helps students develop the creativity and critical thinking skills. The significant pedagogical development in 21st century learning may not be just the continued specialization of knowledge and skills but organizing teaching and learning in ways that infuse arts, math, science and humanities through contemporary real-world curricula (Haddar et al., 2023). In the traditional teaching method, there was no space for enhancing skills through collaborative learning approach as we were made to focus on getting better grades rather than being prepared for future.

In the computer class, while preparing the website on “Mushroom farming”, we could witness the extreme level of dedication when the tasks given to the students meet their interest. One of the participants stated, “*When we get to work on the tasks that are related to our interests, we gain a better understanding*”. Another student added, “*As I want to pursue my future in IT, preparing a website or doing any other computer-related project is an area of my interest*”. The students were happily engaged throughout the learning process. They planned, discussed, teamed up, and put their maximum effort into making their project work. The enthusiasm was vividly seen among the young minds.

Figure 40

Website on Mushroom for the computer project

This effort might have helped them to broaden their understanding in the related concepts. The STEAM learning system fosters collaboration across disciplines, stimulating learners to apply both practical understanding and theoretical knowledge, thereby enhancing their critical thinking abilities (Rosyida et al., 2025).

With the presence of art (A), STEAM has expanded its horizons into a more holistic, interconnected learning experience. Students are encouraged to learn concepts in context, see relationships between subjects, collaborate with peers from diverse backgrounds, and approach problems from multiple angles. Taking example from the STEAM project we collaboratively designed, they worked on engineering principles to build a structure, scientific knowledge about mushrooms, and artistic design for the mushroom house. This multidimensional engagement encouraged students to think critically about how various forms of knowledge can intersect each other and how they can be applied creatively to solve complex, real-world problems. It also fosters a growth mindset, as students often face uncertainty and are challenged to experiment, revise, and refine their ideas and skills that are required for lifelong learning. Furthermore, this collaborative, cross-disciplinary environment reflects the dynamics of modern workplaces and global challenges, preparing learners to navigate and contribute meaningfully to an increasingly interconnected and innovation-driven world. Thus, the STEAM approach not only focuses on academic understanding but also cultivates essential cognitive and social-emotional skills which empowers them to become thoughtful, resourceful, and imaginative problem-solvers.

Again, ourself recalling as a student, we were dependent on rote call memorization as there was no other pedagogical teaching approach. What we did as students in school and early college days was just listen to the teachers, take notes, do written homework, and memorize theories and facts to write on the exam. Learning beyond boundaries was completely missing in the learning process as our learning was bounded within the four walls of the classroom. In fact, we were not privileged enough to have well-equipped learning environments.

Arts and Creativity as STEAM Pedagogy Empowers Students to Become Curious Learners by Analyzing, Interpreting and Evaluating Information

The third theme of this chapter highlights the reality that the skills of analysis, interpretation and evaluation enhance the students' curiosity and transform them into a real learner. While working on the STEAM projects, lots of questions raised from students where they came up with their own creativity. As we believe that every child is unique, we allowed students to explore several STEAM projects, and they did a wonderful job. The students are preparing a model of a satellite. They conducted in-depth research on it, exploring the satellite's working mechanism, how it sends signals to Earth, and the components used in building a satellite. One of the participants mentioned, "*This project helped us to understand how satellites are structured and their revolution around the earth*". Another added, *"We also interpreted how they help in communication and collection of data"*. In this project, students collaborated in Science with computer studies. The participant mentioned, "*As I am always curious about astronomical science, this project helped me to get in-depth information about the satellites, their construction, and their use".* Another participant added *"We really enjoyed building a satellite using locally available stuff and other resources".* They had integrated where coding and decoding were required to send and receive data. Thus, the project helped students experiment, imagine solutions or outcomes, and think critically, transforming the learning process into an active journey of discovery.

STEAM broadens the process of applying scientific process through practical activities and promotes creativity, curiosity and cross – disciplinary studies providing students with a more comprehensive learning environment (Sausan, & Masbukhin, 2024). Unlike traditional education, which often required on rigid problem-solving and technical accuracy, STEAM approach encourages learners to go into scientific inquiries with an open and creative mindset, allowing for experimentation, exploration, and innovation. In our project with the students, we observed the students being imaginative with art work, experimenting the growth of mushroom, fully engaging in collaborative work.

By integrating the arts into science and technology, mathematics, computer and social studies students are exposed to varied ways of thinking and expressing ideas. They gave importance to design, visual representation and real physical work in the mushroom plantation field but not only memorizing and understanding the concept of science in the classroom. Such multidisciplinary approach enhances the learning experience by making students able to explore the connections between separate subjects and apply their knowledge in meaningful real-world contexts.

For instance, designing a good mushroom house required understanding the use of art for aesthetic quality, collaboration skill to work together, mathematical calculations for structural integrity of mushroom house and calculation of the budget, possible profit and loss, analysis of economic potential of mushroom farming in Nepal. Finally, the learning of the scientific aspects of mushroom as a fungus was always there. Through the STEAM project, the students develop not only academic skills but also emotional intelligence, communication abilities, and collaborative competence. As a result, STEAM cultivates a more inclusive and comprehensive educational environment where learners are empowered to become flexible thinkers, innovative problem-solvers, and lifelong learners prepared to navigate the complexities of the modern world

The one more thing we realized through this STEAM project was students and even teachers began to find science and technology in every subject. Like computer is nothing out of science. It is only incomplete understanding that computer is different subject and science and technology is different one. So is the case with other subjects also.

Figure 43
Working and Displaying satellite Model during STEAM exhibition

While brainstorming for another STEAM project, four of the group of students thought of making slime which was fun and so creative. They thoroughly enjoyed the making process of slime where they included the scientific concept polymers where glue reacts with the baking soda. When the project was successfully completed, one of the participants mentioned *"It was so fun to see the unique property of the slime as it's a fascinating subject in science and arts".* They further prepared another fun product 'Oobleck' where water was mixed together with cornstarch. When we asked them about the STEAM in their project, they mentioned "*They incorporated mathematics here where concept of ratio and proportion was included as if the appropriate ratio is not used, it changes the consistency of the mixture". Also, another added "Oobleck is also incorporated in the sensory art project".* Thus, the formation of oobleck and slime enhanced their learning of chemical reactions using fun method.

STEAM promotes curiosity and creativity as it invites children to understand phenomena that are close to themselves or the environment and allows students to encourage their abilities in their own way (Fitriasari et al., 2021). In place of only presenting knowledge or information as abstract or disconnected from students' lived experiences, the STEAM approach is to encourage learners in exploring problems and challenges that emerge from their immediate environment. Such connection to real-life scenario provokes a sense of wonder and inquiry, driving students to ask questions, seek patterns, and explore solutions through both scientific reasoning and creative expression. Taking example from the STEAM project, we observed the students investigate familiar phenomena, such as the weather, plant growth, reusing waste materials. During the STEAM project, they did not only understand the scientific principles behind mushroom's growth and development but also, they were encouraged to represent, model or communicate their ideas using artistic forms such as drawings, paintings and poetry.

Moreover, STEAM empowers students to express their understanding in ways that align with their individual interests, strengths, and learning styles. We noticed some of my students were into arts, some into collecting stuffs, some into designing the mushroom house, some were more focused in learning the scientific aspects of fungi, some were completely into how to make profit, some looked keenly observing the growth and development from the seed and some were more connecting the potential economic growth of the country through organic farming. Similarly, we even read some students' poetry relating mushroom in Nepali and English language classes.

Figure 46

Use of Digital art on Slime and Oobleck

We would like to say this kind of self-directed involvement supports the development of a broad range of skills from critical thinking and spatial reasoning to emotional intelligence and innovation. Students are not forced to stick to one "correct" way of learning or demonstrating knowledge; instead, they are encouraged to explore, experiment, and reflect in ways that resonate with them personally. This individualized approach to education helps foster a deeper sense of engagement, ownership, and confidence in learners, as they realize that their ideas and contributions are valued and valid. Ultimately, by grounding learning in relevant experiences and honoring diverse modes of expression, STEAM creates an inclusive and dynamic educational environment that cultivates both the intellect and the imagination.

Figure 49

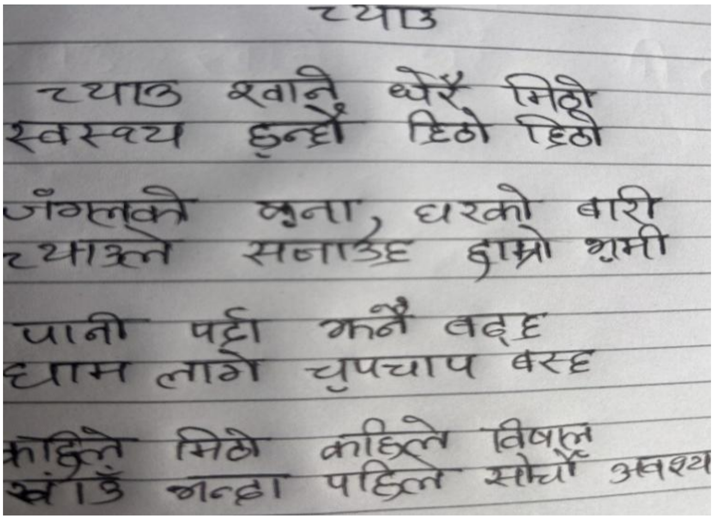
Demonstration on Slime and Oobleck Project

Arts and Creativity as STEAM Pedagogy Is a Reflective Learning Process

While the reflection in their Mushroom project was asked among the students, they performed in several ways where their creativity was vividly observed. Several groups of students came up with their own type of ideas. Some of them wrote a poem, some developed a song, some did a short skit and some wrote a beautiful reflection. One of the students who was more into arts and language compared to technical subjects like science and math deliberately said *"If I had to memorize the facts based on science it would be so difficult to me but this technique of learning science through arts has given me clarity"*. One of the participants beautifully expressed in form of poem and said *"I never knew that scientific learning can be expressed through the means of poem"*. One of the students expressed about the Mushroom in a poem and looking at the my coresearcher (Nepali teacher) was amazed seeing the creativity of students. She smiled and said *"Timro kabita saral cha tara dherai nai arthapurna tarika le prastut garyau, khusi lagy (Trans: Your poem is simple yet very meaningful, I am glad)"*.

Figure 51

Poem on Mushroom



The various forms of expressions really touched my heart. This shows how STEAM helped them to think in the newer ways, use their imagination, and connect science technology and art in meaningful ways. We can connect this kind of learning with the idea of authentic learning since each student learnt out of his or her own interest and opportunity to become actively engaged in the activity they liked.

There is possibility of an authentic learning when there is an active engagement of the student in producing or reproducing knowledge and understanding" (Omollo et al., 2017). This indicated that true and meaningful learning occur not through passive intaking of information, but when learners are free and actively engaged in constructing their own understanding through real life experiences. Inquiry, reflection, and practical application deepen the process of learning. In authentic learning environments, students get opportunities to explore into real-world contexts, engage in collaborative tasks, and come up with meaningful findings that present their learning. This process requires student to connect new information with prior knowledge, relate the concept with real context, and develop critical thinking and problem-solving skills. In place of memorizing facts and following predetermined steps, learners are encouraged to question, investigate, experiment.

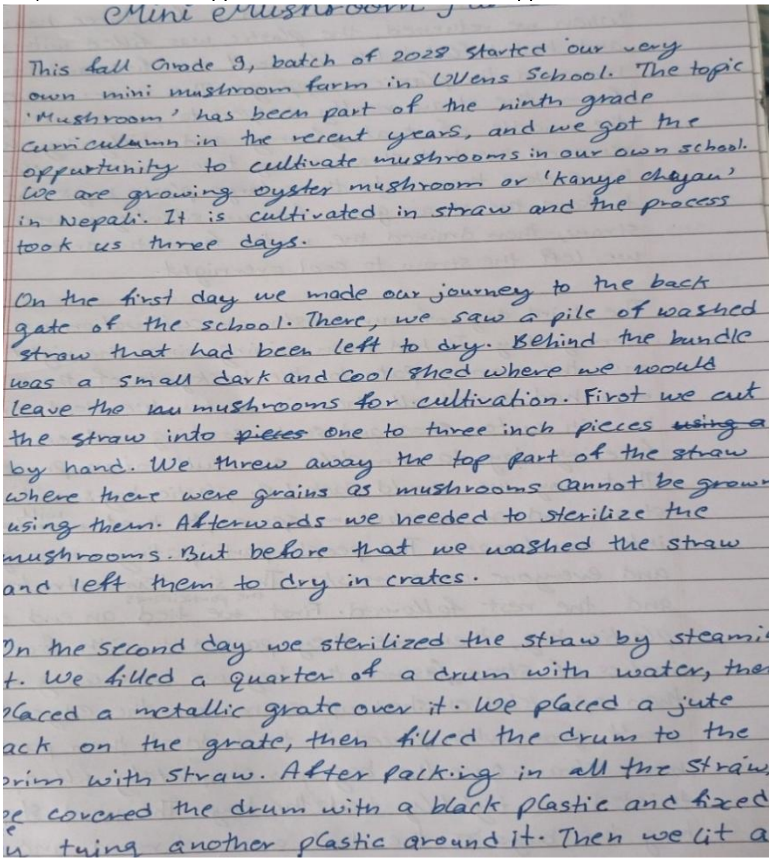
Real engagement in the projects empowers students to become the constructor of knowledge rather than passive recipients, enhancing both their cognitive and emotional investment in the learning process. Authentic learning advocates for the space for multiple perspectives and encourages learners to consider how their knowledge applies in different situations, preparing them for the complexities of real-life decision-making. When the learners take ownership of their learning and see its relevance to their lives, their motivation and curiosity naturally get promoted This active and constructivist approach enhance deeper understanding, greater retention, and a more profound appreciation for the learning journey itself. The ability of art to inspire creativity through scientific thinking, educate young learners in holistic manners, and offer another pathway for making and communicating meaning provide important reasons for integrating arts into science learning (Green et al., 2008).

One of the positive sides of integrating art with other subjects is it motivates the students to focuses on not just intellectually but emotionally and imaginatively, fostering deeper levels of curiosity and exploration. In the artistic activities, students can involve in drawing scientific observations, designing models, composing science-inspired music, or dramatizing natural phenomena. Through such involvement, they can visualize, reinterpret, and internalize scientific concepts in ways that traditional methods may not allow. This multisensory engagement helps bridge the gap between abstract theories and concrete understanding, making science more accessible and meaningful for diverse learners.

Additionally, integration of art helps holistic education by addressing cognitive, emotional, and social development at the same time. Usually, we find science often emphasizing logic, accuracy, and structured inquiry, whereas the arts introduce openness, interpretation, and personal expression. Integration of arts allows learners to develop empathy, resilience, and communication skills but not only scientific literacy. This combination helps to create not only informed thinkers but also reflective, creative, and socially aware learners. Additionally, the arts open the space for the alternative modes of communication, which are especially important in inclusive classrooms where students are with multiple intelligence. Integration of art empowers all types of learners including visual, auditory, and kinesthetic to participate and succeed in science learning. Ultimately, the integration of the arts into science and other subjects is not merely an enrichment activity but a vital pedagogical strategy that transforms science education into a more dynamic, inclusive, and human-centered experience. The integration of art has helped learners to connect knowledge across disciplines in meaningful and lasting ways. This showed us that arts have helped to inspire creativity by encouraging students think beyond fact. Here we feel contextual to mention one more memory of my school days where the art-based activities were considered as the extra-curricular activities but not required as real learning. Connecting art with major academic subjects like science and mathematics was not in

Figure 54

Reflective writing on Mushroom Farming

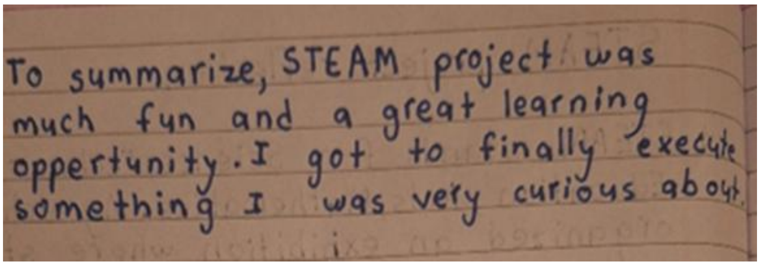

Mini Mushroom

This fall Grade 9, batch of 2028 started our very own mini mushroom farm in UWens School. The topic 'Mushroom' has been part of the ninth grade curriculum in the recent years, and we got the opportunity to cultivate mushrooms in our own school. We are growing oyster mushroom or 'kanye chyau' in Nepali. It is cultivated in straw and the process took us three days.

On the first day we made our journey to the back gate of the school. There, we saw a pile of washed straw that had been left to dry. Behind the bundle was a small dark and cool shed where we would leave the ~~mu~~ mushrooms for cultivation. First we cut the straw into ~~pieces~~ one to three inch pieces ~~using a~~ by hand. We threw away the top part of the straw where there were grains as mushrooms cannot be grown using them. Afterwards we needed to sterilize the mushrooms. But before that we washed the straw and left them to dry in crates.

On the second day we sterilized the straw by steami t. We filled a quarter of a drum with water, the placed a metallic grate over it. We placed a jute ack on the grate, then filled the drum to the rim with straw. After packing in all the straw, e covered the drum with a black plastic and fixed it tying another plastic around it. Then we lit a

Figure 57
Short reflection on STEAM project



practice. We took all the students of grade nine to a Mushroom farm and research center located at Bhaktapur. There we met an expert who described and showed us the Mushroom that is grown in his center. He highlighted on the economic and health benefits of mushroom. Students has fruitful interaction with the expert. Students also observed the machinery equipment required for the mushroom farming. Mr. Bam (Mushroom expert) said *"I started this farming in small scale with very little knowledge about it but now I have expanded it to a research center and even I export my production to international markets"*. He is not just involved in mushroom farming but also in manufacture of mushroom extracted medicines and in research field. Many of the students mentioned "*Although the visit was not comfortable as it was all muddy, slippery and hot but then it was worth enough in terms of learning"*. Some of the students also got the packed Raato Chyau as medicine for their parents and grandparents as it was considered suitable for treating diabetes, high BP. All the students were asked to bring a detailed reflection of their visit to have an overview on their trip. Each of them had their own type of experience, however one shared *"we were very excited during the trip, and we could closely monitor the mushroom cultivation in large scale in detail"*. They were heartily thanking me for the opportunity. The reflective activity shows that the reflection from students highlighted a range of aspects of description, analysis and self – evaluation,

Figure 60
Mr. Bam Displaying his production

Figure 63
Students Posing after Buying Medicinal Mushroom

learning and implications and the development of these skills require constant repetition and feedback in order to occur (Pretorius & Ford, 2016).

Digital Arts and Technology as STEAM pedagogy for Dynamic Visualization of Complex Concepts of Science

This theme highlights the integration of digital arts and technology in learning. Digital art refers to the art that relies on computer based digital encoding and processing of the information in different formats as texts, numbers, images, sounds in which art- making can incorporate computer based digital encoding (Thomson-Jones & Moser, 2015). This allows artists and learners to explore creativity, experimentation, and new form of expressions beyond traditional art method. One of the major things that we observed during the STEAM project was integration of technology in learning makes big difference. The students of present time are very much connected with the technology in their day-to-day life. It was overwhelming to go through the reflections of the students about they thoroughly enjoyed the STEAM projects as they explored several new things. Students prepared presentations in their respective groups while integrating economic activities to highlight the importance of mushrooms in trading. The creativity and the innovative ideas were vividly seen in their presentation. One of the students mentioned "*Digital art helps to illustrate the concepts creatively and helped to understand complex ideas easily*". Other responded *"This diagrammatic presentation is best example of art integrated science learning". Meanwhile other speaks "Art is everywhere, we only need to identify and utilize it wisely in the disciplinary subjects".* Yes, art is all around us in nature, stories, books, etc. In education we just need to recognize where art fits to make learning more creative and meaningful. The application of digital technology has become an important component to help students acquire 21st century skills including critical thinking, problem solving, communication, collaboration, creativity and digital literacy (Ezell et al., 2020).

Today's world is a rapidly evolving, tech-driven world, having competency in these areas is no longer optional but essential for the success of the students in both academic and real-life contexts. Digital tools and platforms provide dynamic learning environments where students od have enormous access to resources, engage with interactive content, and participate in authentic tasks that indicate challenges found in the workplace and society.

As some instances from my STEAM project, students presented their ideas through the digital arts and digital presentation. Also, they developed the website in which they could showcase the entire process and engagement in the mushroom project. The project which was germinated in the science class ultimately got to incorporate the idea of different subjects including computer and digital technology. Such integration allows the learners to experiment the digital technology and gain the very important skills required in day-to-day life.

In the same way, digital technology also broadens creative possibilities by engaging students to prepare multimedia presentations, digital art, videos, website, or interactive models, giving them the freedom to express their understanding in the ways of their interest. These opportunities to create and share digital content do not only enhance engagement but also empower students to take ownership of their learning and contribute meaningfully to their learning communities. Importantly, such integration also promotes digital literacy equipping students with the knowledge and skills to navigate, evaluate, and responsibly use information and media in a digital age. Students gain the opportunity to learn the thoughtful, responsible and purposeful use of technology through such integration.

Figure 66

Digital Art on Economic Importance of Mushroom

We noticed many students being able to express their ideas with creativity and confidence. Hence, learning has become engaging, meaningful and interactive. Informtaion and communication technology (ICT) one of the emerging technology that has been a great help in teaching and learning and has helpd to make lessons more interactive and developed creativity among the students. Considering its importance ICT has become a crucial part in science curriculum of Nepal government. While learning the topic ICT, we allowed students to explore all forms of technological platforms on their own where they had to pepare a summary report of their research. One students mentioned *"Learning Science through ICT is so amazing"* . As they were allowed to use their devices like smart phones and other devices for research and exploration, then we added *"As you all are Gen alpha, you all are growing in the age shaped by digital technology".* The research was integrated with computer science where they had to use their own creative ways to explore, computer teacher was glad and said *"How* *keen and excited they were into their tasks when they were allowed to use technological devices".* Each student had to use their device and explore several social media platforms to research and send their writing or data to one of their classmate. Students used gmail, tiktok, viber, whatsapp, snapchat, messenger to communicate among their friends.

Figure 69

Email by a Students as a Part of Integrated Approach in ICT

आई.सी.टी. भनेको सूचना सञ्चार प्रविधि हो। यो जानकारी साझा गर्ने उद्देश्यका लागि प्राविधिक उपकरण र स्रोतहरूको विविध सेट परिभाषित गर्न प्रयोग गरिने शब्द हो। यो जानकारीको प्रसारण, भण्डारण, साझेदारी, सिर्जना वा विनिमय गर्न प्रयोग गरिन्छ। यो इ-कमर्स, बैंकिङ, व्यापार, सञ्चार, शिक्षा, चिकित्सा, आदि क्षेत्रहरूमा लागु हुन्छ। इन्टरनेट र वाइफाइ दुवै आईसीटी अन्तर्गत पर्दछन्। इन्टरनेट नेटवर्करुको नेटवर्क हो। इन्टरनेट प्रयोग गरेर हामीले सर्भरबाट जानकारी प्राप्त गर्न सक्छौँ साथै सर्भर वा डाटाबेसमा भण्डारण गरिएको जानकारी र अन्य विभिन्न प्रकारका डाटाहरू सर्च इन्जिनहरू मार्फत प्राप्त गर्न सक्छौं। वाइफाइ वा वायरलेस फिडेलिटीले डाटा प्रसारणको लागि रेडियो वेभको मद्दतले नोडहरू जोड्ने गर्दछ।

उपग्रहहरू मानव निर्मित यन्त्रहरू हुन् जुन पृथ्वीको वरिपरि एक विशेष कक्षमा परिक्रमा गर्दछन् र यो दूरसञ्चारका साथै वैज्ञानिक अनुसन्धान र पृथ्वीको अवलोकन गर्नका लागि प्रयिग गरिन्छ। उपग्रहले पृथ्वीलाई तल्लो पृथ्वी कक्ष, मध्यम पृथ्वी कक्ष वा भूस्थिर कक्षमा परिक्रमा गर्छ। अपलिङ्क र डाउनलिङ्क सङ्केतहरू भू-स्टेशनहरू मार्फत उपग्रह पृथ्वीद्वारा दिइन्छ र प्राप्त गरिन्छ। नेपाली साट १ नेपालको पहिलो उपग्रह हो । क्युबिकल नानो उपग्रह भएकाले यसको तौल मात्र १.३३ केजी थियो। यसमा नासाको आर्थिक सहयोग र निर्माणमा आबास मास्के र हरि श्रेष्ठ संलग्न थिए । यो अप्रिल १८, २०१९ मा भर्जिनिया, संयुक्त राज्य अमेरिकाबाट लन्च गरिएको थियो र नेपालको परिदृश्यका तस्विर खिन्न प्रयोग गरिन्छ।

दूरसञ्चार भनेको इलेक्ट्रोनिक उपकरणहरू प्रयोग गरेर डाटा पठाउने काम हो। यसको आवश्यक तत्वहरू हुन्: सूचना, इनपुट ट्रान्सड्यूसर, ट्रान्समिटर, च्यानल, रिसिभर र आउटपुट ट्रान्सड्यूसर। सञ्चारको यो विधि प्रयोग गर्दा जानकारीलाई विभिन्न फ्रिक्वेन्सी वा एम्प्लिट्युडमा परिवर्तन गरिन्छ (मोड्युलेसन) र अन्तमा जानकारी निकाल्नको लागि क्यारियर सिग्नललाई डिमोड्युलेट गरिन्छ। यो प्रक्रिया मोडेमद्वारा गरिन्छ।

This was also integrated with Nepali language and English language where both the language teachers had to check the sentence structure and the grammatical errors. Nepali language teacher added *"Nani babu haroo le ICT ko baare ma ramro sanga khoj garera dherai ramro tarika le ya prastayeka chan (Trans: students have really done good research and expressed so clearly about ICT)". She also added " Maile hijje, byakaran, bakya herda paani ramro chan kehi sudhar garnu cha ma tesma uniharoo lai chahine sujhab dinchu (Trans: I have checked spellings, grammar, sentences which are very good however some corrections are needed for which I will provide them required feedback)".*

In science learning, ICT can be used by teachers to improve students cognitive and affective abilities, present innovative and creative concepts, motivate and increase students interest in learning as it is one of the basic skills that must be possessed by 21st century students (Suryaningsih, 2023). Use of ICT makes teachers feel it is important to present scientific concepts in more innovative, engaging, and creative ways, thereby making abstract or complex topics easier to understand and more relevant to students' everyday experiences. Teachers and students both do not disagree that ICT is deeply rooted in their life. A very important thing is knowledge of ICT, which is one of the most required for the 21st -century. Today's students are like digital native who have seen the digitization of the world from their childhood. They have no other choice but only to be eqquiped with advanced digital technology. Engaging with ICT tools in the learning project allows them to develop essential digital literacy skills, including the ability to access, evaluate, and communicate scientific information using a variety of digital platforms.

Integration of ICT into science education, teachers create a more student-centered, inquiry-driven learning environment that prepares learners not only to excel academically but also to thrive in an increasingly digital and information-rich world. Therefore, ICT is not simply a teaching aid; it is a vital component of modern pedagogy that supports holistic student development and brings science education into alignment with the demands and opportunities of the 21st century.

Connecting the above-mentioned agrument in my research, we observed the students fully enjoying and learning not only science and other subjects through ICT but also learning ICT through the entire projcet. We never thought this approach would be so helpful for the students. We find new generation students very fortunate as they have excellent access to technological advancement which has made their learning very promt and detailed.

Despite the fact critical thinking, creativity, digital literacy, teamwork, and communication skills are essential for employment in a globalizing digital economy, they are not enough for transforming unsustainable practices in the home, community, and workplace (Taylor, 2019). This argument indicates an important difference between acquiring skills for employability and developing the deeper values and characters who can contribute in society. While 21st-century competencies such as problem-solving, collaboration, and technological proficiency are undeniably vital to cope with the demands of a fast-changing, globally connected economy, Taylor (2019) further argues that these alone cannot address the root causes of social, environmental, and ethical challenges we face today.

Transforming unsustainable practices requires more than technical knowledge; it demands critical consciousness, ethical reasoning, civic responsibility, and a commitment to long-term collective well-being. Individuals must be equipped not only to adapt to the world as it is, but to actively reshape it into one that is more just, equitable, and sustainable. This involves rethinking consumer habits, advocating for social and environmental justice, and making informed decisions that go beyond personal gain to consider broader community and planetary impacts. Education, therefore, must go beyond preparing students for the workforce and also cultivate values, empathy, ecological awareness, and a strong sense of agency. Taylor's perspective calls for an educational model that integrates sustainability, ethics, and transformative action into its core,empowering learners not just to succeed in the economy, but to contribute meaningfully to a more sustainable and compassionate world. This extended argument of Taylor (2019) is presented here because we found the students very much into the digital world for anykind of learning and creation. Also what we realized was such involvement in the digital learning must be shaped rationally so that they can develop themselves as a good human being in true sense and can contribute to the society in real meaning. Thus, the integration of digital art and computer science can enhance the learning of the students but at the same time such integration must be addressing the individual and social need at the same time.

Theoretical Connection

Taking insight from the thematic discussion presented above, this heading presents how STEAM approach to learning and teaching is connected with critical theory and constructivism.

Though critical thinking and scientific reasoning might sound similar, they are differently constructed understanding. Halim and Mokhtar (2015) mention that scientific knowledge is well constructed through inquiry, where critical thinking skills are required to verify information if they are true or not. Both require higher order cognitive process, metacognitive strategies, and intellectual outcome which help individuals making meaning of information (Dowd et al., 2019). The connection between STEAM and critical thinking looks direct and significant. STEAM empowers students to become more inquisitive, analytical and evaluative in their learning process. Such, inner qualities cannot be developed without acquiring strong critical thinking skills. Kivunja (2015) defines critical thinking as a cognitive process which empowers individuals to interpret, analyze, and evaluate information, arguments, or experiences with a reflective attitude. Collaboratively, these perspectives highlight that there is a vital role of critical thinking in meaningful learning and knowledge construction. Similarly, critical thinking makes students creative to understand scientific concepts, as they critically inquire their prior understanding and tend to explore alternative solutions. The integration of art in STEAM strengthens the process by encouraging imagination, reflection and innovation in solving problems. Thus, STEAM approach to education promotes fosters deeper and more critical engagement with learning.

Through artistic expression or interpretation, students create new idea and turn that idea into some tangible stuffs. Such creation usually does not happen in isolation rather than is possible in collaboration among each other. It means learning takes place in society but not in isolation. Students gain experiences through artistic creation. These ideas, collaborative work and experiences support students to construct new knowledge. Dewey (1938) explains learning as a social activity which is students do together and in interaction but not in isolation. Thus, we can connect the STEAM project in which the theory of constructivism was reflected in students' learning.

Vygotsky (1978) emphasized learning as a socially mediated process, stating that "learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment." (p. 90). This perspective indicates the importance of the role of social interaction in cognitive development, suggesting that knowledge is not constructed in isolation but through engagement with others. Constructivism theory of Vygotsky (1978) further state that the learning of the students is supported by the more knowledgeable others. Such 'others' can be peers, teachers, and anyone from the community. In our research we observed students' learning being supported by their own social interaction, peers, teachers of different subject, mushroom farming experts etc. Students learnt through their own innovative ideas and even the guidance and instructions of the teachers also supported them to implement the idea of mushroom farming. According to Vygotsky, learning precedes development, meaning that through guided participation and dialogue, children are able to perform tasks and understand concepts they could not grasp independently. This idea is central to his concept of the Zone of Proximal Development (ZPD), which defines the gap between what a learner can do alone and what they can achieve with assistance. Within this zone, learning is most effective because it stretches the learner's current abilities with the support of social interaction, often referred to as "scaffolding." These interactions serve not only as sources of information but as catalysts that help internalize thinking processes and build higher-order cognitive skills. Vygotsky's theory thus shifts the focus from learning as an individual endeavor to a collaborative process rooted in culture, language, and community, underscoring the importance of communication, shared meaning-making, and the social context in all forms of education.

Vygotsky (1978) argued that every function in the child's cultural development is observed in two different level. First, on the social level, and later, on the individual level. Connecting this statement with the learning of my students through the STEAM project, we observed the students socially interacting with peers, teachers and more knowledgeable other from the community to learn or to construct the knowledge. Similarly, later the idea they grasped from the society became their own authentic knowledge. Thus, Vygotsky's core belief that social interaction is foundational to learning and development applies in my research also. It illustrates how knowledge is first co-constructed in social settings before being internalized by the individual.

Supporting the idea of constructivism, Khan (2019) states that students' prior knowledge and their active participation play a vital role in knowledge construction. This argument aligns with the foundational principles of constructivist learning theory, which emphasizes that learners are not passive recipients of information and date, but they are active agents who build new understanding by connecting it to what they already know. It believes everyone is likely to have some prior knowledge out of his or her experience. When they bring their existing knowledge, experiences, and perspectives into the learning process, they are better able to interpret, organize, and make sense of new information. This active engagement allows them to construct meaning in ways that are personally relevant and cognitively meaningful.

We relate this argument with our students bringing the idea of making mushroom house, idea of drawing and painting to make it more aesthetic, the knowledge of digital presentation, idea of economic condition of the country etc. Whatever the students had already known, they used all that knowledge to make the learning better.

Khan (2019) further highlights that meaningful learning occurs when students are encouraged to question, explore, and interact with ideas rather than simply memorize content. Active participation, such as discussing, experimenting, problem-solving, and reflecting, enables learners to test their assumptions. They also confront misconceptions and refine their thinking while learning process. We noticed students arguing with each other when the idea did not match. They had an interactive discussion in the class, they were happy and unhappy with each other while working in the field of mushroom farming.

This dynamic process not only deepens understanding but also fosters critical thinking, creativity, and independence. We even witnessed the students who had critical opinion about the whole project with their own logic. We remember a student saying the STEAM project was not meaningful and learning for all the students. Furthermore, recognizing and valuing students' prior knowledge creates a more inclusive and learner-centered classroom environment, where diverse backgrounds and experiences become assets in the co-construction of knowledge.

Chapter Summary

This chapter examines how integration of arts as drawing, model making, digital art, and other design activities supported students' creative engagement, conceptual understanding and problem solving in science classrooms. The several art-based activities encouraged imagination, multiple ways of representation, collaboration and active meaning making. Moreover, connecting ICT in science has not only developed cognitive aspect but also helped in the affective part of the students. This has empowered diverse learners creating an inclusive learning environment who struggle with traditional, text- based instruction. We realized the emotional aspect of the students and also the transformation of the team of teachers involved in the process in terms of the pedagogical approach.

CHAPTER VI
MY REFLECTIVE JOURNEY

This final chapter is not just a summary but a reflective and analytical synthesis of entire research journey. I have presented my critical reflection of the entire research journey in different sub-headings. Each sub-heading presents the actions and their relevance in a critical way. Similarly, at the end of each sub-heading, the reflective and concluding paragraphs are included and this reflective chapter discussed the research's outcomes. How STEAM pedagogy enriches science learning is well explained in this chapter. The chapter concludes the research journey.

Transformative Journey from a Conventional Practitioner to a STEAM Educator

I would like to begin this section with this beautiful quote "Success is not final, failure is not fatal; It is the courage to continue that counts". Thus, we have begun to believe that perseverance is more valuable than single outcome. Moreover, this mindset is so crucial for educators and learners like us as it encourages embracing challenges, learning from mistakes and never lose hope. We believe this transformative journey in practicing STEAM has taken us to the next level which we had not have imagined for myself before we started the research. Now, I can say I am not a same science teacher as I was before conducting this research. I no longer see science as a single discipline. Same applies in case of my co-researchers. What we feel now is we are slowly shifting towards light from the darkness. We also have started to understand what STEAM is all about and what participatory action is all about. At the same time, I have found my co-researchers realizing that the collaborative teaching effects students' learning positively. They have begun to discuss the further possibility of designing the project for the students in which all the teachers can work together.

During the beginning of the journey as a novice researcher, we came across with several skeptical thoughts and questions. We had several questions and doubt related to PAR and my own involvement into the research as;

- *Do we have enough theoretical and methodological understanding for conducting research?*

- *Will this research contribute meaningfully to our growth professionally and personally?*

We were not clear whether we would be able to do justice with the research method and approach that we had selected. That's why we can say that our PAR journey is one of the unforgettable memories of our entire life. At the end of the research, not only we realized a major shift in our thought processes but also, we have found changes in our action related to teaching and learning process. In our opinion, we did not only learn the technical aspects of research and pedagogical aspects of STEAM from this research but also working very closely with the students inculcated the feeling of empathy inside us. Similarly, we have found ourselves emerging as a critical self- reflector. As a teacher, we have started using reflection to assure ourselves that the planning and implementation of our teaching as a teacher meet the need of every student in our class or are we well known about the learning ability of every student we deal with. We keep on thinking whether we understand every student's learning way and make him/her learning effectively or we just teach. We guess nowadays our focus is more on learning than teaching.

We relate our journey with the transformative learning theory of Mezirow. We believe the support of our experience to take further actions aligns with the transformative learning theory. Learning is a process of utilizing prior interpretations to construct new or revised interpretations of the meanings of one's experiences and using this as a guide to action (Mezirow, 2000, p. 5). Our learning involved accumulating better meanings by re- working the existing meanings and learning new one.

Concluding this heading, the involvement in STEAM project through participatory action research became a transformative journey for us both personally and professionally. The start with doubt and uncertainty gradually got clear and confident as we proceeded further into research. Now, for us, learning is an ongoing meaning making process rather than a product or result oriented project. Such process goes through collaboration, active engagement and continuous critical reflection. The experience we gained through the research has helped us to reshape our identity as a teacher-researcher, who emphasizes on learners' prior knowledge, learners' need and learners' way of learning. We also realized how meaningful is it for a teacher to become an empathetic person and self-reflector. Our journey even aligned with

Mezirow's transformative learning theory, reflecting a shift in perspective acquired from experiences and translating new understandings into action. From one angle, this research has empowered our knowledge of STEAM and participatory action research and from another angle the same research has paved the path for more thoughtful and reflective teaching-learning activities.

Framing the Research Questions

When we reflect back to our journey of the participatory action research, we remember every phase equally tough but interesting. After problematizing our experience and opinion about the STEAM pedagogy, making research questions was a very challenging job for us. As a researcher, it seems clear what we want to find out but it is equally difficult to frame such desire into some specific questions. Our research questions not only led us what to find out but also, they oriented us towards the right direction in order to explore and obtain the answers of those questions.

As we noticed during the beginning that most students were not motivated to learn Science which resulted in passive participation in the learning process. The main reason that made us to reflect on our own teaching and learning practices was continuous observation of students' classroom behavior. Some questions used to constantly trigger us as a teacher are;

- *Why are our students are not actively engaged in learning science in the classroom?*
- *What aspects of the science teaching methods can be limiting students' motivation?*
- *How can we make my science teaching more enjoyable to the students?*

Several questions used to be being popped out of our mind continuously. Hence, we searched better ideas to make learners participate actively and explore possible pedagogies for making teaching learning better. Among several pedagogies, we chose STEAM pedagogy in our class and for that we framed research questions based on the problem we encountered.

We believe that we are able to address both the research questions and fulfill the research gap. The first question "How does STEAM pedagogy engage students in meaningful learning of Science?". The novice researcher recognizes gaps in their knowledge or just realize about not being certain about their choices as this might raise interest in knowing more about the problem which triggers engagement in learning activities resulting in increased knowledge.

The student's reflections, engagement in the activities demonstrated the excitement and curiosity in the several activities. Due to time constraints and lack of appropriate trainings, collaborative activities happen to be difficult which was the major challenge faced during the research.

Now after this research we have strong fascination with the word meaningful learning. We continuously question ourselves "Are we able to make meaningful learning among our students?" In our past few years, we have been exploring several teaching methodologies to make learning fun and meaningful but among all, STEAM pedagogy has brought significant change in the process.

Our second research question is "How does STEAM pedagogy integrate art and creativity in science classroom? Integrating art with science blended creativity with inquiry. Students explored scientific concepts through artistic expressions. This made learning more fun, engaging and meaningful. Students designing mushroom growth chart, posters, 3D models demonstrated creativity as they are able to visualize scientific concepts. However, due to several other challenges as time constraint, lack of flexible curriculum policies and resources limits students' empowerment and creativity. Art has a special and separate space in my heart. Though I am not so artistic kind of person, I get very much fascinated with any genre of art. I believe art is language of soul and bridge between imagination and reality. Though colors, shapes, sounds, movements, art helps us to connect with the world in a beautiful way. We really enjoyed this part of our research process while working with our participants and art teachers. It has been suggested that science education often emphasizes cognitive aspects and neglects emotion although emotion and cognition are interrelated in science learning and emotions can be emphasized by using various forms of arts in science teaching (Turkka et al., 2017).

Leaving the good part aside, we also cannot forget those struggling days of our research as we were finding difficulty for giving a kick start to our research. It was almost impossible to align everyone and make them seat in the same boat. It was like pleading people for favors. We find mixed group of people in our society or community. I always have my sincere gratitude to the ones who always stood by my side during the hard times and there comes some who took this process like a burden due to which our research process took significantly longer time. At some moments we felt like quitting this research. But we believe the growth, lessons, hinderances, discoveries have shaped us and our thoughts and we acknowledge all the challenges we faced throughout the journey as we feel that this part has made us stronger. Despite all these we are glad that we could bring prominent changes in the learning outcome and the pre- conceived notions that teachers used to have on collaborating teaching for the betterment of the students.

In conclusion, reflection of our research in which we participated and travelled through a journey discloses a process of constant challenges, critical queries, and meaningful learning. As participatory action research is specific in particular case which cannot be same in another case (McTaggart. et. al, 2016), we have our own experience in this project. When we began the research, we were concerned over students lack of interest in engagement in learning science and technology. But as we progressed with STEAM pedagogy, we found students' disengagement gradually transformed into a purposeful exploration heading towards meaningful learning. One of the features of the participatory action research is that it is a democratic process which liberates participants, enhance their learning and functions with equity (Kach & Kralik, 2006).

Through the journey, we got our research questions addressed and our understanding of learning redefined adding new elements of teaching as reflective and learner-centered. The integration of art and creativity played a role of powerful catalyst between the student and the concept of science for effective learning. It encouraged students to be inquisitive in the classroom, which supported for deeper understanding of scientific concepts. Ultimately, learning of scientific concept became both enjoyable and purposeful for students. Despite the research process made us anxious in the beginning due to various hinderances, delays and doubts, those all became vital sources of learning and empowerment for us. At the end, this experience has reinforced our trust for the pedagogy which includes collaboration and innovation. It has questioned our understanding about teaching and learning. It has also acknowledged our belief on possibility of meaningful transformation in teaching learning process, which is possible to be achieved through reflection, persistence and collaboration.

Selecting Research Paradigm, Research Approach and Research Methods

Being a student of research in KUSOED, I had opportunity to learn about various research paradigms, approaches and methods. Since being the student of natural science, my orientation was to quantitative research. I had heard of qualitative research but had no idea and experience of involving into qualitative research method. First of all, fitting science and technology into STEAM was a qualitative approach. From the beginning of the first semester, I began to learn about qualitative research as an appropriate method for the research related to STEAM. The classes of different academic courses, dragged me to critical and interpretive paradigms. Emphasizing on reflective and collaborative learning for STEAM pedagogy in class discussion slowly raised my interest in critical paradigm.

When we selected to follow interpretive and critical paradigm for the research, we had to select one of the appropriate research methods. Our research questions were guiding us to select the students as the research participants. We had to make meaning from the real practice of STEAM pedagogy in the science classroom. Thus, we needed the support from the teachers of different subjects. In the beginning, we thought of a case study of using STEAM pedagogy in science classroom but STEAM is not only about science. The involvement of other subjects was equally important. Then we thought about Participatory Action Research (PAR). My supervisor and mentor also suggested me to select the PAR as the research method. Though we were convinced with the method, we were not confident about using the method. Or, we had several confusions and fears about using such method. Observing the participants from outside and questioning them as an interviewer was completely different from being the participant of the research that we ourself were conducting. We had hope from the participatory action research giving us the best result of the research but how to achieve that best result was unknown to us. Yet, we jumped into the field approaching PAR as the savior. The challenges came instantly. It was not easy job for me to convince my colleagues, the subject teachers, to involve in STEAM project and participate in the research. Teachers, who were used to in teaching standalone subject, had difficulty in collaborating with each other and involve in the project. Anyways, all got convinced and began the project.

In this way, my academic journey helped me to go beyond the comfort zone of quantitative research, which I was familiar with in earlier days. KUSOED taught me to value qualitative approaches in STEAM education. We got exposure to critical and interpretive research paradigm which changed my lens to view research and classroom practice. Though it was not easy for me, I selected Participatory Action Research. Several fears and confusion at the beginning hesitated me with the PAR.

Being a researcher and participant at the same time was not only an interesting job but also a tough task we selected. The difficulty began with convincing different subject teachers to collaborate across subject and engage students in learning. Nevertheless, we had to accept such challenge as a researcher. Participatory Action Research taught us how to make meaning from real classroom practice. Similarly, we learnt how important it is to collaborate and reflect for real and effective learning. Active and real participation from our co-researchers and participant students made the project lively and vibrant. We found a kind of excitement in the participants and co-researchers because they were very happy to do something in real. For the fellow teachers, working on a real project was new and challenging. From the traditional classroom teaching, they had come out to the mushroom, something concrete. Likewise, for the students, it was a new experience because they were touching, smelling, and feeling. The beauty of participatory action research was reflected when the students were experiencing the scientific concept.

Unlearning to Learn

Unlearning is as equally difficult as learning. In fact, the entire content of this chapter is all about the reflection on unlearning. Actually, my unlearning process had begun when I joined the university.

When I entered the journey of my MPhil in STEAM education at Kathmandu University, I had high hopes and expectations. KU itself is a brand for strong academics in Nepal and on top of that Kathmandu University School of Education have a separate swag in teaching and education field. I was fascinated with such academic charm of the KUSOED. My main motto of joining the course was to update my knowledge and teaching practice in response to changing educational needs. Yet, I had not thought what I would achieve and what changes I would find within myself.

The academic journey did not only change our lecture-based approach but also it transformed our habit of content-focused teaching. We began to inquire ourself whether all the students were participating to learn in our classroom. In fact, we became doubtful if the real learning was happening in our classes or not. Slowly, we felt the need of the move to concept-based learning from the content-based teaching. Similarly, we started focusing on learner-centered and inquiry-based approaches. We explored the theoretical aspects of STEAM pedagogy and began to practice STEAM in classroom connecting with real-life contexts. We found lessons and concepts becoming really meaningful and relevant to students' real-life experiences. Through this process, our role as a teacher also changed from a transmitter of content to a real supporter of the students to understand the concept. Now, we think we are growing as a reflective practitioner, who observes, questions, and keeps upgrading in teaching methods. I faced several challenges to cope new ways of thinking about STEAM pedagogy because I had academic background of a pure natural science, Masters in microbiology and understanding of traditional teaching approach. We were trained and easy to objective knowledge, fixed procedures but the research we conducted was more subjective and reflective with multiple interpretations. Concepts of reflective writing, inquiry-based approach, and theoretical framing were so much unfamiliar to me. Such unfamiliarity developed lack of self-confidence and we began to be self-doubtful. Despite having all those hindrances, we gradually became able to cope all the difficulties. Our teachers, mentors, supervisors and supportive classmates did a lot to make me feel easy. Similarly, our own constant engagement in reading, writing and participation in discussion supported me to be familiar to the new system.

During my MPhil classes, we got opportunity to participate in several academic discourse which supported our learning significantly. These discussions encouraged deeper thinking and critical reflection. We had several group activities, sharing and various other engaging activities that helped to transform our ideas and beliefs. We had to prepare and present frequently on various topics which provided opportunity to articulate our ideas confidently and also helped to learn from peers, know their perspectives. Also, the reflective assignments helped us to connect theory with our own experiences. From all the above activities, I could feel my academic writing, my communication skill, reflective capacity and my overall growth is gradually being enhanced as an educational researcher.

I was always curious and enthusiastic to find and apply better teaching practices in my classroom after I started my MPhil journey along STEAM pedagogy. In my classes I started to use several engaging practices for students, hands – on activities, projects, field trips, mini- exhibition that helped to enhance several soft skills among my students. This not only helped to develop their skills but also helped them to have clarity in the concepts which led to have better outcome in both formative and summative assessments. During the research, we deliberately began to explore the root causes of the challenges we observed in the science classroom within the STEAM education framework:

- *Why were learners not interested in learning science?*
- *Why did they seem bored or disengaged during science lessons?*
- *How could we shift their perception of science as a meaningful and relevant subject?*
- *And how could we better engage them through integrated, hands-on, and creative STEAM approaches?*

Our primary objective is to adopt integrated curricular approach in teaching science to prevent from disadvantages of fragmentation of subjects. Moreover, this helps to integrate art and creativity in science using STEAM pedagogy. The STEAM plan and implementation complements to a learner understanding of a subject in a better way. Through the process of integration, we want to make sure all the essential skills required for students in their near future such as critical thinking skills, creativity, communication skills, IT skills, social skills, etc. In this process of collaborative learning approaches, students get to develop their holistic aspect by solving the problems in real worlds.

Concluding this heading, we can say the journey of unlearning and learning again has been a deeply transformative journey for us. We were forced by ourselves to question our long-rooted belief of teaching and learning process. Gradually we moved away from lecture-based and content-focused teaching method to concept-based, learner-centered and inquiry-driven approaches. Such move is an indicator of ourselves being transformed. We began to practice STEAM connected plans for different disciplines including real life context of the students so that we could make the learning interesting and meaningful. Though the shift was difficult and unclear in the beginning, the support from the mentors and colleagues made it possible. From taking the teaching as a task with burden, we started to enjoy engaging students into meaningful projects. Now, we consider ourselves not only as a subject teacher of our respective disciplines but also a critically reflective practitioner. We are fully aware of students' need and learning ways. This journey enriched our belief in integration, creation and collaboration in teaching. We believe our unlearning and learning support our students' better learning.

Understanding Self and Role as a Researcher

Beginning from the days during my second semester where I thought of exploring a research topic for the research proposal as a requirement of STEAM research class, I brainstormed and had discussion with my classmates and my teachers about several possible topics. I had strong curiosity and fascination with Participatory Action Research as I was dealing with critical and interpretive paradigm, I wanted to bring transformation in teaching learning process. I always used to have some critical questions raised in my mind as;

- *How can we implement STEAM practices in my teaching which can be different from my past teaching practices?*
- *How do our beliefs about teaching and learning influence this research?*
- *How can we remain ethical and reflective while working with our own students?*

After a long brainstorming and discussion, we decided the research topic on STEAM as "Enriching Science Education through STEAM: A Participatory Action Research". Through this action research, as a science teacher I wanted to implement STEAM in my science teaching to bring a difference. Even before starting this research, I already had started practicing several methods of integrated teaching and learning like art-based teaching science, planning collaboratively with other subject teachers for transdisciplinary themes. We organized diverse activities for the students which were engaging and fun.

While introducing the concept of materials used in daily life and ecosystem in grade nine, we asked students to divide themselves into five groups and each group had to choose one choice among the five forms of art as poem, role play, music, story and visual art to express scientific understanding creatively. Students' deep engagement and ownership of learning was reflected in their work through their enthusiastic participation. The students showcased their final work among other students as well as other teachers which was praise worthy. We really enjoyed the entire process and the best part was students did not take the task as a burden instead they thoroughly enjoyed the process. Moreover, we take students for trip-based learning in ICIMOD where Science can be connected to several other aspects as economy, agriculture, language and many more.

After numerous feedbacks from my supervisor regarding my proposal, my proposal was ready for the defense. The day for my proposal defense was decided where I got numerous feedback and suggestions for the correction. With strained and breathy voice, I shared my presentation on my proposal. What a relief it was? After taking a long breathe, I relaxed and stretched out my body thinking that I am one step ahead of my MPhil journey.

Then we reached the third trimester which was so fun as during this semester we got an opportunity to have field visits and in person classes which helped us to build rapport among our classmates to whom we never met in person and also our respected teachers whom we used to enjoy listening for three hours virtually. I still remember while studying “STEAM teaching and learning”, our teacher Ms. Roshani took us for a visit to a school named as Shree Janahit Secondary School located at Dapcha – 9 Kavre. This school has been involved in several project interventions under Kathmandu University School of Education. We collaboratively were divided into groups and asked to prepare a lesson plan for the implementation among the students of grade nine in the same school. The title of the presentation was “Irrigation and Flood Control in Rice Farming” as the case study was contextual to the area as “Farmers in Dapcha village facing irrigation and flood issues”. We collectively prepared a plan to make students learn about the challenges of irrigation and flood control in rice farming and also to develop problem solving skills to address these challenges.

During the third trimester in our research class, we were supposed to share our update and progress on our research for the dissertation. In my case as I have chosen PAR on teaching science using STEAM which was a collaborative task. Here I had to select, ask consent and bring all of them in the common ground. It is like keeping them in the same boat which I am using to cross the huge river. It’s not a simple boat, it’s a huge ship and crossing the river is a difficult task as there was strong water current, wind and other obstacles. Here, we metaphorically described how difficult was it for me initiate the field work for my dissertation. Implementing a pure STEAM education in our current education system is purely a utopia as there are plenty of challenges that teachers must cope with (Milara & Orduña, 2024). And I critically asked some questions to myself to assure or cross check about my own thoughts;

- *How does the concept connect to STEAM pedagogy and meaningful learning?*
- *How clearly will we be able to explain the purpose of research to my co-researchers in simple languages?*

Looking back to the journey of our research, we find it as a continuous process of inquiry, exploration, and transformation. The thing started as a requirement of the STEAM research slowly became a deeply personal and professional exploration for us. Our curiosity of earlier days about Participatory Action Research got rooted in our desire to bring real transformation in the teaching practice.

We had carried the critical questions among us, which shaped not only our research topic but also our identity as a teacher-researcher. Making the topic *"Enriching Science Education through STEAM: A Participatory Action Research"* allowed us to align our views with our actions. We desired to move beyond traditional teaching and create meaningful, creative and student-centered learning experiences. As we stated implementing STEAM practices in the classroom, we saw a notable shift in students' engagement and ownership in learning. We designed activities with integration of art collaboration and real-life experiences transformed science lessons into joyful and meaningful experiences. Students expressed their understanding with confidence and creativity and learning felt natural rather than forced. Experiences such as trip-based learning and collaborative planning with other teachers further strengthened our belief in integrated and experiential education.

At the same time, the research process itself was not less challenging. Preparing for the proposal defense, receiving critical feedback, and initiating fieldwork demanded patience and resilience. Engaging in PAR made us realize that transformation is not linear or easy. Rather, it requires trust, communication, and shared purpose. Although implementing STEAM fully may seem idealistic within the current system, this journey has taught us that small, reflective actions can create meaningful impact. Above all, this experience has strengthened our commitment to ethical, reflective and transformative teaching and research practices.

Collaborative Learning in Action

As we had planned to stitch to the curriculum, we had to choose suitable concept for the research to begin and also it should align with concepts from other disciplines that we have planned to integrate. During the process we could also not detach from the philosophy of the school hence following its norms and values. Now we had to discuss and decide on co- researchers (fellow teachers) which was another strenuous job as they are not only the participants but also an active collaborator in the research process. They were chosen purposefully based on their relevance, willingness and capacity to contribute meaningfully to the study. Initially, we had a talk individually to check their interest and took a little bit of idea on their curriculum. Later after several round of talks, when some clarity came among all the co-researchers (teachers), we sat for a group meeting to make everyone reach a common ground. As teachers involve multiple content areas during their teaching, an important factor of STEAM teaching is for teachers to consider the discipline or content areas necessary to solve the problem (Quigley et al., 2017).

Now it was turn of selecting key participants (purposeful selection of grade nine students) for the research. We collaboratively selected the students as they provide rich, relevant and diverse insights into their learning experiences. The selected students represented varying academic abilities, gender, interest and engagement levels. We selected twelve key participants from diverse backgrounds ensuring them about their confidentiality and took consent from them as they are going to be part of the research work. These selected key participants were so delighted to be a major part of the research process. After we selected the key participants, while we called out their names for individual talk, they were so amazed about being called for a meeting. Later after we briefed them about the role and responsibilities and how they are going to be the integral part of our research work, participants (students) started feeling comfortable and had more curiosity about what they are supposed to do in future.

Once the co-researchers and key participants were finalized, we collectively sat together for the final integrated teaching plan. With several revision, suggestions from supervisor, school heads and my co-researchers, we successfully finalized the lesson plan ready for the implementation.

Honestly speaking it took me almost a year to begin this project. Some of my mentors said “Hyaa madam yo PAR methodology chai dherai nai garho huncha (Trans: PAR methodology in research is very difficult to accomplish)”. The idea of shared ownership and participant voice made us feel complex at the beginning. Planning actions collaboratively, adapting strategies as the situation demands lot of patience. However, engaging in repeated cycles of planning, action, observation and reflection strengthened my confidence. This challenge helped us to grow stronger as a reflective practitioner and a researcher. There were times where I used to feel like;

- *This way I will not be able to complete my thesis so I may have to quit.*

- *This research methodology has been troubling me a lot, if the university allows me I will change the methodology.*

I still remember our head of department of STEAM Education respected Binod sir during the last day of our MPhil class saying that many students avoid contact with their respective supervisor regarding update about their dissertation. They even stop picking up calls and eventually students end up quitting their dissertation. At this stage of completing your third or final semester, you all have just completed 40% of your MPhil study, now remaining is 60%. So, he requested all of us to engage in continuous work.

We found some co- researchers so reluctant that they were hesitant to begin the research due to the fear of additional workload and continuous reflection of their practices. We recall days when we had to make constant follow-up and informal discussions to convince some of the co-researchers to make them ready for the planning and implementation. Even at this stage I felt like if it was a different methodology, I would have completed my dissertation at least one year earlier.

When we reflect on this phase of the research journey, we realize that Participatory Action Research is deeply shaping our thinking and practice. Selecting concepts from the curriculum, school philosophy and multiple disciplines required careful planning and constant effort on that. Selecting co-researchers needed a procedural and relational task. Working with fellow teachers is not possible without collaborators trust and support, patience, and common understanding.

Reaching a common ground was not possible without regular conversation and collective planning. This process made us realize that the STEAM project is not possible only with individual effort but with collaboration among diverse disciplinary perspectives. It required the purposeful selection of student participants, which further strengthened the ethical and reflective nature of this research. Sense of ownership in learning and constantly raising curiosity were possible only when there was engagement of the students as active contributors rather than passive receiver. Such engagement, excitement and expectation provided meaning to entire process. Additionally, constant feedback from supervisor, mentor and school leaders enhanced both academic and managerial aspects of the research. However, the journey continued along the difficult path. Our patience and resilience were well tested by prolonged preparation period, unwillingness of co-researchers, and my own limited understanding of Participatory Action Research. At a time, we questioned ourselves whether PAR was our correct choice or not. Yet, our confidence got gradually built due to cycle of planning, action, observation and critical reflection.

As we assessed students' need, we got deeper insight into how they want to learn and what could be the better ways for them to learn. We came to know students like active engagement, interaction and practical experience. They love collaborative work and explore ideas beyond the textbook content and love to go beyond the four walls of classroom. We felt the meaning and worth of collaboration and exploration in learning very clearly. Similarly, it built our belief in STEAM as a meaningful pedagogy stronger. STEAM does not only allow students to explore the theoretical aspect of any scientific concept but also it proves that concept practically with real life situations. We found STEAM providing space for the students to think, inquire, create and critique.

STEAM workshop with fellow teachers was both challenging and rewarding. To work with experienced and skilled teachers needed adequate planning and thoughtful moderation or facilitation. We had to respect their knowledge, experience and professional way of working. We found the workshop with teachers creating an intellectual space for conversation, sharing and mutual learning. We learned from each other through the dialogues and reflective opinions. Such experience focused the meaning of peer learning and reflective practice in professional growth.

Overall, the journey supported us to transform ourself from an ordinary teacher to grow as a reflective practitioner. We realized that meaningful change in education takes time, which requires continuous effort with collaboration and patience.

Collaborative Workshop for Meaningful STEAM Application

In this heading, we are going to discuss about our PAR journey during which we were able to gather several beautiful memories and along with that some depressing moments where we almost gave up but tried our best to stand tall despite of several hindrances. The journey was not easy though. Several times while reflecting upon our own experiences we realized that we could do better than we did. This is what learning from mistakes might be called. My PAR process exactly matches some key components of PAR given by Morales (2019) as the following; 1) a focus on change, 2) context-specific, 3) emphasis on collaboration, 4) a cyclical process, 5) liberatory, 6) PAR is not just another method, and 7) success is some personal or collective change". We have tried to address all the major key components of the PAR while carrying my STEAM research.

We started the journey with a workshop to educate all the teachers of the school where we were planning to conduct PAR. Me along with my colleague conducted 2 hours' workshop on the STEAM pedagogy on meaningful teaching with all the teachers of grade 6 - 10 within the school premise. All the teachers actively participated in the event. We began with an icebreaking activity (human knot) in two groups followed by brainstorming session on STEAM using technology called as mentimeter. All the teachers had to brainstorm three words related to STEAM. Most of the words used were integration, collaboration, creativity, technology. It was then followed by some questions with a short video that gave an overview about what STEAM education is and its application for holistic development of students. We presented some slides introducing STEM/ STEAM where we shared principles of STEAM education and its urgency in today's world for the development of the 21st century skills that is required for the learners to immerse into their learning. We shared sessions to explore innovative STEAM pedagogies and approaches. Also, we had developed two STEAM lesson plans which we shared among the participants to have an idea on the planning and implementation. All the teachers seem to be very excited and enthusiastic during the planning. During the planning session all the teachers were divided into groups where brainstorming and intense discussion on the planning had happened.

In the following PD session, teachers came up with very creative ideas. It was a wonderful sharing session where we could explore many possible ways of integration of subjects and beyond. We believe planning and implementation on this particular sharing session has given us more insights on the STEAM pedagogies. Teachers professional development are of more importance when they do not focus on the subject rather they focus on the methodologies which helps to transfer practices with 21st century skills that in turn meets the needs of the students (Conradty and Bogner,

Figure 72

Teachers Planning for STEAM Lesson Plan

2020). Through this workshop we wanted to ensure STEAM in every day school life promoting contemporary teaching in respective disciplines.

As the feedback of the session, all the teachers seem to be very excited and totally engaged in the workshop. One of the teachers mentioned *"The theme of the entire plan so based on STEAM starting from the human knot as ice breaker activity, using mentimeter as a technology or the STEAM plan itself".* Some other mentioned *"We did not realize how 3 hours passed by".* These words were really motivating for us. Taking the sample plan as reference and referring the curriculum, we teachers developed a STEAM plan on topic Mushroom as the first cycle.

We shared a google doc for brainstorming and jotting down the ideas and plans for the implementation. All the teachers from the respective disciplines were equally putting their effort. Eventually we developed a STEAM plan for the topic Mushroom. After the plan was developed, the principal and the vice principal of the school gave us some feedback and suggestions. Based on the suggestions, we slightly changed the model of the plan. When the plan got approved from both; school where we were conducting the PAR and my supervisor, I really felt that we achieved something big. We still can remember to reach at this state, I required lots of follow up, patience, planning.

After we planned, now we jumped to other challenges like finding appropriate timing, expert, area, further plan and many more. Due to several limitations, we were only able to integrate five subjects including mine as Social Studies, Nepali language, Computer, Science and Visual arts.

Continuing to reflect critically on our PAR journey, we realized that we got a mixed bag of a joy, struggle, learning, and growth. Many beautiful moments encouraged us to move forward and many difficult moments gave our examination. Many times, there were difficult moments when we felt low and almost gave up. Through reflection, we realized that making mistakes is an unavoidable part of learning. Each challenge taught us how we could do better than in earlier times. The key components of PAR, such as change, collaboration, context, and continuous reflection were aligned with the research process. Our effort was to address these elements throughout the STEAM research journey.

In the beginning of the research, workshop was a meaningful step for the STEAM project. Teachers participated in the workshop actively which gave me confidence. The collaborative planning sessions were useful which allowed teachers to share ideas freely and creatively. Seeing teachers enjoy the activities and lose track of time was deeply motivating for me. The feedback from the teachers assured us that STEAM pedagogy can create engaging and meaningful learning spaces for teachers as well as students. Working together on STEAM lesson planning supported us to understand the effectiveness of collective thinking and shared ownership.

It was not an easy process to develop and improvise the STEAM lesson plan. It needed patience, regular follow-up, and acceptance on feedback. Getting approval from the school leadership and our supervisor felt like a major achievement. Even after planning, new challenges kept emerging. My commitment was tested by time management, resources, and subject integration. Despite the above-mentioned hindrances, integrating multiple subjects was a significant success.

Igniting STEAM in and Beyond the Classroom

In this section of the reflection, we are bringing a memory how we began to teach the concept of mushroom in the classroom as the STEAM project. During this, the very first day, we started with warm – up activity and then we checked their prior knowledge through several thought-provoking questions. We used KWL chart for the same. After checking their prior knowledge, the students were shown some pictures and videos using the smart board where they could have ideas about Mushroom, its farming and its importance.

The students were then divided into smaller groups and posed few questions as;

Where are Mushrooms found?

What type of organisms are Mushroom?

In what type of environment do Mushroom grow?

Why Mushroom are consumed widely by us?

What are the benefits of Mushroom farming?

Based on the given questions' students had rich discussions, explored the answers through various sources as reference book, google, etc. and were asked to jot down key points that come out from their discussions.

We consider trip-based learning to be a vital component for connecting classroom education with real-world experiences. With the STEAM approach, integrating the curriculum of the different subjects of grade nine, we planned a trip-based learning to mushroom farming center for our students with strong belief that this visit will significantly enhance our students; understanding and practical knowledge in the area of mushroom cultivation.

This very day, we were excited to experience about the first day of the STEAM implementation. As per the planning, we visited Mushroom farm which is located at Thimi, Bhaktapur. Few days ago, we were looking for a place where we could connect our curriculum to the real world while planning the unit. During this process, we were able to explore one of the renowned Mushroom farms named as Mushroom Seed Nepal and Research center. This place is not only involved in mushroom farming, it is also into several research on varieties of Mushroom found in Nepal and throughout the world. This research centers provide trainings to the people from various part of Nepal who are interested in Mushroom farming in their own area. We were glad and curious to know how the director/ owner of the farm, Mr. Adesh Bam has reached to another level of success in Mushroom research and farming despite not having any formal higher education in Science. He shared us how he was inspired to become a farmer, do something on his own and also contribute to the nation and the society. He shared us the structure, lifecycle, reproduction, and economic advantages of Mushroom. We all were excited to see the various forms of Mushroom being grown in his farm. He basically had three types of Mushroom at present; Shitake, Red mushroom and Kanye Chyau. Among three, Red mushroom is known to be of great importance and very expensive compared to other. It was known to treat some diseases as blood pressure, diabetes, cancer, etc.

He also offered the medicine made from red mushroom in some special discount where some students brought it. In addition, he showed us the devices and containers where the substratum for the growth of the mushroom is sterilized.

In the following day, students were asked to reflect upon their experiences on the trip to Mushroom farm. All of them came up with varieties of sharing where most common thing was *"We had a fun learning"*. As per many of the students they said that they enjoyed the trip-based learning and also had very good learning where they could connect their learning to real life. Moreover, students also enjoyed the trip through the bus and in the farm itself. However, they mentioned about some discomfort they had during the trip. As it was a bit moist and rough area in rural settings, they had a complain about the space that was quite difficult to accommodate 64 students. It was really hot and the area itself was very slippery for us to walk. The instruction time was more than the actual visit which they were looking forward for.

Now it was time to work collaboratively with our co- researchers and participants. After having one round of meeting with the co-researchers we decided to begin the collaboration. This part was very tough as it was difficult to implement the planning parallelly in all five subjects. Several hindrances included were procrastinating nature, other school activities disturbing the classes, lack of collaboration, and many more. At some state, we used to feel like we have chosen the wrong methodology and this methodology is not going to work. Getting determined and motivated alone was not enough in this process. Along with myself being prepared we had to follow up and motivate co- researchers which was not an easy task though.

Empowerment was not only limited to the students as it expended to my fellow colleague (Nepali teacher). In her reflections she noted that this collaboration helped her to experiment with designing lessons that combined scientific concepts with creative and practical applications. She is very prompt and active co- researcher (Nepali teacher) who planned to integrate with her topic **"Kareshabaari".** She had two classes on this particular topic where she started with brainstorming questions, discussion and reflections. In this topic students are meant to learn how vegetables can be grown and how the small kitchen garden can be used to grow nutrients rich food. She also described about the importance of organic farming and its major health benefits. She emphasized on the use of the kitchen garden for growing vegetables and stuffs for both economic and health benefits. The session continued with few brainstorming questions on some nutrient rich foods and their importance. Moreover, students had a rich discussion on how Mushroom plays a vital role in ecosystem.

Nepali teacher gave an overview on different types of farming.

Based on the essay "Karesabaari" students were posed following questions;

करेसाबारी भनेको के हो?तिम्रो करेसाबारीमा केके लगाइएको छ ? (Trans: What is kitchen garden? What have you planted in your kitchen garden?)

करेसाबारीको उपयोगबाट कसरी फाइदा लिन सकिन्छ? (Trans: What advantages can be taken from use of kitchen garden?)

जस्ता प्रश्नहरूका उत्तर छलफल गर्ने! (Trans: Similar questions were discussed)

रासायनिक खेतीका बेफाइदाहरू केके हुन् ? (Trans: What are the disadvantages of chemical farming?)

Moreover, students were given a class assignment where they were asked to write a description on करेसाबारीमा मलखाद प्रयोग, सिंचाई र गोडमेलका बारेमा पाठमा व्यक्त विषयवस्तुप्रति आफ्नो धारणा व्यक्त गर (Trans: Express about the use of fertilizer, irrigation and nurturing in the kitchen garden).

For this question students had to write description related to Mushroom farming procedure in their own kitchen garden and highlight about the importance of farming mushroom in their own area. Moreover, they emphasized on the benefits of mushroom in terms of health and nutrition. Later, we had conversation with Nepali teacher about how she experienced integrating theme with other subjects. She told me that she was very comfortable and teaching students about Kareshabaari was easy, and she felt that she taught something real and something she knew well.

Simultaneously, in their DOE skill (art) class, my research participants, along with the co-researcher, had already planned a creative idea for developing a mushroom house as part of their visual art activity. They also developed a very attractive and colorful basidiocarp of a Mushroom. Doing this, they gained an in-depth understanding of the structure and stages of mushrooms. The courage to imagine the unimaginable is a valued trait for both artists and scientists; art is created through the beautiful skill of imagination, which explains why artistic processes in science might be valuable (Turkka et al., 2017).

All the students were provided with the required materials, including clay, a tissue roll, aluminum foil, and a glass jar. Through this activity, students were able to integrate art-based learning into science. In addition, students prepared designs for the house's doors and windows. During the process, collaboration, teamwork, and critical thinking skills were evident. Using this integrated approach, students were able to explore and illustrate the structure of a mushroom and its life cycle.

Next week's project, “Mushroom house,” in integration with arts, was completed. In this project, students finally developed different types of mushrooms in art class using clay, paint, and a paintbrush. Completion of this project helped them to explore the structures of different types of mushrooms. By doing this, students were able to design mushrooms, including their structures and characteristics.

After exploring a suitable person (Mushroom expertise) for in-house mushroom farming. We had several meetings to make the mushroom farming possible within the school periphery. We explored a suitable area for farming. One of my hectic jobs was to deal with the school management regarding the area where mushroom farming was supposed to take place. As the criteria for the room were specific, it should be dark and sufficiently moist for the growth of the mushroom. With the full support of the school's management and supporting staff, we finally made the room ready for mushroom cultivation. Not just the room; we also ordered the required materials for mushroom growth, including hay, large metal containers, wood, plastic trays, mushroom spawn, plastic pouches, gloves, and masks.

Meanwhile, after several follow-ups, another co-researcher (a social studies teacher) began implementing the integrated plan. In this particular integration, students were briefed on the economic activities that happen through various methods. During this, students will research the situation of Nepal's industry and trade, the mushroom industry in Nepal, and the mushroom products supplied to national and international markets. Through these, students can explain the importance of mushroom cultivation, its products, and its benefits to the national economy and trade.

These students were divided into groups and assigned presentation topics, where they conducted extensive research and gathered information on the entire process of mushroom business and trading to enhance the nation's economic importance. They sorted the different types of mushrooms that can be cultivated in Nepal, which was clearly presented in a tabular form.

Simultaneously, on the other hand, we were already set for grand mushroom cultivation in the school area. This year, we embarked on a fascinating journey to provide students with a practical learning experience on growing mushrooms. This term, students have been learning about mushroom cultivation, which started with a visit to a mushroom farm in Bhaktapur. Students were engaged with our long-awaited grand STEAM project on cultivating mushrooms. The task was supposed to be done for three consecutive days. On the very first day of our mushroom cultivation, students were introduced to a mushroom specialist who guided us through our project. We started with a brief introduction and a plan. It began by cutting both wet and dry straws into small pieces measuring 1-2 inches with a hand-operated straw-cutting machine. One by one, all got to experience how to cut straw, and students also enjoyed it while doing so. Both grade 9 sections took turns cutting the straws, and by the end of the day, all the straws were ready to be used.

At around 3 pm, some of the students gathered to wash the straws. We started by putting the straws in a drum, which was quite challenging and a laughable experience. After pressing the straws down in the drum, we added water to completely submerge them. 30 minutes later, we removed the straw and placed it into 8 crate boxes, which we left in our shaded area to let excess water drip off.

The second day of our mushroom cultivation began with preparing a metal drum to put in our straws. The drum was filled with water, and a jute fabric was placed on top to prevent the straw from coming into contact with the water. The straws were taken out of the crates, and our specialist had mentioned that there shouldn’t be any excess water when wringing the straws. However, when we tried doing so, some water dripped down, indicating that our straw wasn’t dry enough. Yet, our farming continued because there wasn’t sufficient time to let it dry.

Next, we put the straw on top of the fabric and pressed it down with a stick to ensure that it all fit. Subsequently, we turned on the heat to sterilize it. This process made sure our straw was bacteria-free and sterile. When the fire was lit, it was green at first, which was very enchanting to watch.

On the last day, putting on masks and gloves, the sterile straw was transferred into plastic bags. Layer by layer, the straw and mushroom spawn were kept alternatively in 12-inch clear plastic bags. Eventually, there were five layers, so we tied the plastic bags. At the end, names were written on the bags, which made our mushroom farming very memorable. Finally, the bags were put into a well-covered area with warmth and humidity.

With this, the three-day-long journey came to an end. Throughout the three days, it was very exhilarating to grow our own mushrooms. With the cooperation of the students, our specialist, and school management, our mushroom farming endeavor has been a success. Now is the time for us to observe and wait patiently as our mushroom grows. While regularly observing for a few days, the mushroom seemed to be spreading through the plastic bag, which generated varying levels of excitement, but, unfortunately, it did not grow as expected.

After multiple investigations, the hindrance to the proper growth of the mushroom was found to be contamination. To address this, we held a meeting to analyze and discuss the issue and share observations. The discussion helped us understand the challenges in scientific experiments and encouraged us to think critically about the next steps that can be taken to improve results in the future. We were really disappointed, but then realized learning happens through process more than the product.

Meanwhile, some students were busy preparing the website on Mushroom farming as a part of integrated learning with computer science. In this case, students have developed a website “Mushroom farming”. This website provides all the important information about the mushroom. This gives information about things like,

- What is Mushroom?
- Types of Mushrooms
- How is the Mushroom cultivated?
- Benefits of Mushrooms
- Process of Mushroom farming

Students of grade nine developed a project named “Mushroom farming” integrating computer and Science. Science is used for the information and content, while the computer part is used for HTML and CSS to create the website. The website includes an introduction to mushrooms, their types, impacts, uses, and the varieties found in Nepal. The information was gathered using AI, a web browser, and many other search engines. This is mainly focused on mushrooms grown in Nepal, such as Button mushrooms, Shiitake mushrooms, Oyster mushrooms, and Immortality mushrooms, which have cancer-curing properties originating in China. Similarly, integrating science with ICT, where students had to share their reflective learning process through technology.

In this reflective learning process, students were able to explore the information and communication technology by preparing the presentations using several ICT tools as Canva, PowerPoint, Word, Excel sheet, Email, and other web browsers to write, share, and present their research work, field work, and learning process among their teachers, classmates, and parents. During this process, they prepared a Word document based on their fieldwork, in which they outlined the entire procedure of Mushroom farming and the experiences they gained during their participation. This write up was firstly shared and presented with rich discussion among the classmates, and later was emailed to parents and teachers to make them aware of their grand event.

In addition to the above-mentioned integrated approach, we planned a mega event, STEAM Expo, where students developed and demonstrated several STEAM projects. In this event, students showcased their creativity through math, science, computer science, the arts, and language. They prepare models, experiments, games, quizzes, etc. in their exhibition.

Students explored the concepts of science and technology and mastered 21st-century skills such as creativity, critical thinking, collaboration, and integration, presenting diverse projects. Some of the projects included an added element of fun, like themed games, which made them even more exciting. Their showcase wasn't just about projects; it stood as a testament to their growth and the joy STEAM education brings by integrating subjects such as social studies, math, the environment, computer science, languages, and the arts.

Emotional intelligence was demonstrated through their increasingly successful collaborations throughout the week. The collaborations included more supportive behaviors from students, such as pausing their work to help other students when they struggled (empathetic behavior). This eagerness to help and to share their burgeoning knowledge with one another demonstrated the group's cohesion. Integrated science, technology, engineering, arts, and mathematics (STEAM) activities provide opportunities for students to creatively engage in authentic problem-solving activities. Each subject focuses on problem-solving in different ways.

Finally, reflecting on the STEAM project on mushrooms, we consider it one of the most meaningful phases of my PAR journey. The project began with simple classroom activities but later expanded into deep, real-world learning. Warm-up activities and prior knowledge checks helped me gauge how much students already knew about the concept. We used tools like the KWL chart, pictures, and videos to make the lesson engaging from the very first day, so that students were curious and eager to learn. Their group discussions showed active participation and ownership of learning.

Trip-based learning played a vital role in this project. Visiting the mushroom farm in Bhaktapur connected classroom concepts with real-world practices. Students had the opportunity to learn from a mushroom farming expert and observe the varieties of mushrooms, the techniques of mushroom farming, and the economic benefits. They enjoyed the visit and described it as "fun learning." They shared both excitement and discomfort in the reflection, which showed honesty. The field trip helped me realize that learning environments can be improved and are not always perfect. The changed learning environment is important for the students to learn in a fun way. The field trip taught students that learning goes beyond comfort and classrooms.

The collaborative phase of the project was both rewarding and challenging. Working with co-researchers across subjects demanded patience and regular follow-up. At times, we felt discouraged and doubted my decision to pursue PAR. However, seeing progress in action renewed my motivation. Learning became richer and more meaningful from the integration of language arts, visual arts, social studies, computer, and science. Students connected the concept of mushroom farming to health, finance, profit and loss, the economy, the ecosystem, creativity, and technology. Art activities helped them understand structure and life cycles. ICT activities enhanced communication and presentation skills. Social studies helped them see national and economic relevance.

The school-based mushroom farming became the most exciting part of the project. Students were fully involved and actively engaged in every step. They cut straw, sterilized materials, filled bags, and carefully observed the process. Even though the mushrooms did not grow as expected due to contamination. But the failure of the growth was not the failure in learning. The learning became more powerful when students witnessed the problem in the mushroom growth. Students learned that failure is part of scientific inquiry. They reflected, discussed, and suggested improvements. This experience taught all of us that learning lies more in the process than in the final product.

The study's findings offer insights into how schools and communities can implement practical agricultural learning to promote hands-on learning, collaboration, and sustainable development. From this, national policy can be informed as the strategies are highlighted, integrating sustainable, locally relevant projects blending with modern technology into the school curricula across Nepal. Globally, many countries face problems with abundant resources, where findings can provide guidance and models for several other contexts for linking education to the community.

To conclude the project, we organized a grand event as “STEAM expo”. Students confidently showcased their projects. They demonstrated creativity, collaboration, empathy, and critical thinking. They supported one another and worked as a team. This project stated my belief in STEAM and PAR. We believe the project strengthened our identity as reflective practitioners. It presented to us that meaningful learning happens when students are engaged, trusted, involved, and connected to real life.

Systematic Alignment of STEAM (Implications of the Study)

The study and findings of the research imply that contextualized STEAM pedagogy, implemented through participatory action research, has the potential to transform science education in Nepal for future practice.

- Implications for teachers: Teachers need support in designing interdisciplinary projects, assessment strategies, and the use of local resources. Reflective cycles help teachers to improve their practice.
- Implications for curriculum developers: Curriculum developers can rethink how the secondary curriculum is designed and move from subject silos to an interdisciplinary STEAM framework.
- Implications for policymakers: Policymakers should encourage integration of STEAM education in national education strategies.

Conclusion

This reflective chapter includes the overall journey, findings, and learning gained through the implementation of STEAM pedagogy using Participatory Action Research. Effective and understandable learning of scientific concepts is important for students in the present time. Learning science helps students make sense of natural and real-world technological phenomena. When STEAM pedagogy is incorporated into science teaching, it also enhances students' critical thinking. 21st century learners must have critical thinking, collaborative, and scientific knowledge application skills. STEAM pedagogy proves to be a meaningful and effective approach to developing these skills among the students.

The meaning we have drawn from this study or the research's findings indicates that teaching science through STEAM created a more engaging, inclusive, and learner-centered classroom environment. The STEAM approach motivated students and engaged them in active learning. They actively participated in hands-on activities, worked collaboratively, and expressed their understanding through multiple forms, including art, presentations, discussions, and projects. STEAM pedagogy taught students to connect scientific concepts to real-life scenarios, enhancing their understanding and making learning more meaningful and deeper. The shift from teacher-centered lecture to learner-centered practice was clear, as students took ownership of their learning and demonstrated improved confidence, creativity, and problem-solving skills.

This chapter also presents reflections on my personal and professional transformation as a teacher-researcher. When we engaged in PAR, we required patience, collaboration, reflection, and resilience. Although the process was marked by several challenges, delays, and moments of self-doubt, it empowered our reflective practice and helped us grow as educators. Collaborative planning with co-researchers, active student involvement, and continuous reflection were the keys to the success of the STEAM project. Even challenges such as unsuccessful mushroom cultivation became valuable learning opportunities, reinforcing the idea that learning is rooted in process rather than product.

Though STEAM pedagogy enriches science education, implementing the STEAM project requires careful planning and systematic support. Educational authorities and stakeholders should work to develop the agenda of establishing STEAM not only as a teaching approach but also as a learning culture in schools and include it in the curriculum. Curriculum design, assessment systems, and teacher evaluation should focus more on real-life competencies, creativity, collaboration, and critical thinking rather than simply completing the yearly course on time and delivering the content. Overall, this study argues that STEAM pedagogy, supported by reflective and participatory practices, has the potential to transform science education and better prepare learners for future challenges.

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APPENDIX I

Workshop Plan with School Teachers

Teacher's Professional Development Workshop on STEAM Education for School Teachers [Grade 6-10]

Date: August-25 and September-2 (Both Sunday)

Venue: School auditorium hall

Facilitators: Isha Basnet and Upama K.C.

Program Schedule

1st day

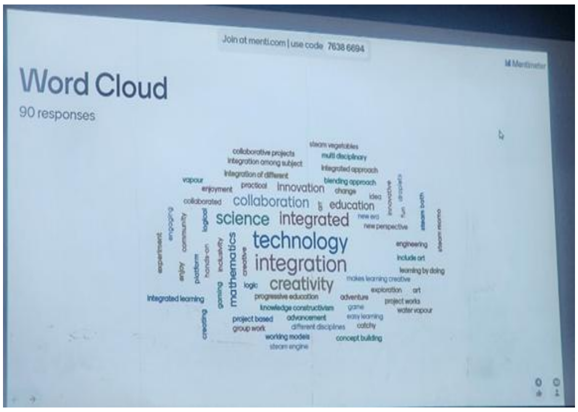
Session	Activity	Time
1. Ice breaking activities	Human knot game	15 minutes
2. Do now activity	Word cloud game	15 minutes
3. Understanding STEAM	Slides and video on STEAM education	30 minutes
4. Lesson plan	Overview of a sample lesson plan	30 minutes
5. Group work	Planning of integrated (STEAM) plan	1 hour

2nd day

Session	Activity	Time
1. Ice breaking activities	Warm up activity	15 minutes
2. Do now activity	Guess the word	15 minutes
3. Group work (Cont…)	Finalizing the plan	30 minutes
4. Sharing	Group sharing of the plan (each group)	1 hour
5. Feedback and discussion	Peer feedback and feedback from principal	1 hour

APPENDIX II

Sample of activities during a teacher workshop session



APPENDIX III

Guiding Questions for Need Assessment (For teachers)

1. What are the different methodological approaches for teaching your subject?
2. Do you include collaborative, hands- on or creative activities in your teaching approach?
3. What difference have you experienced in your teaching styles and your teachers' styles in how you were taught?
4. What kind of pedagogical difficulty are you facing in your profession?
5. Have you ever tried to collaborate with the teachers of any other disciplines in your teaching practices?
6. Do you have any idea about STEAM education? If yes than what do you know about it?
7. Have you ever tried any type of innovative pedagogical practices like project-based approach, art-based approach?
8. How comfortable are you in using technology in your subject?
9. Do you have any suggestion for interdisciplinary activities or projects to engage students creatively?

APPENDIX IV

Guiding Questions for Need Assessment (For students)

1. What do you enjoy most about science learning?
2. Which part of science lessons are difficult or less interesting for you and why?
3. How do you like to learn about science concepts?
4. What creative activities do you like to do in your science classroom?
5. Do you use computers, mobiles, other devices while learning science? How do these help you?
6. What would make science learning more interesting and easier to understand?

APPENDIX V

Timeline of Participatory Action Research

The timeline of the participatory action research (PAR) is shown in the following table.

Cycle - 1

SN	Date	Action work
1	August 19 2024	Short meeting with Vice principal regarding the STEAM workshop
2	August 23	An email was dispersed among teachers regarding STEAM workshop
3	August 25	Workshop on STEAM education for teachers of grade 6 - 10
4	September 2	Follow up on STEAM workshop
5	September 26	Pre- trip activity and group discussion on mushroom
6	September 27	Trip based learning to mushroom farm (Bhaktapur)
7	September 28	Reflective writing on Mushroom farm
8	September 29	Integrated learning mushroom with Kareshabaari
9	September 30	Art based learning of science (Chart paper work, mushroom clay model, digital art)
10	October 2	Website demo on “Mushroom farming” in collaboration with computer
11	October 3	Mushroom and integrated learning with economic activities in social studies
12.	October 4	Reflection sessions + Interview and discussion among the participants
13.	October 6	Planning and preparation for cycle 2

Cycle - 2

12	October 7	Inhouse mushroom farming (Cutting straw and soak in water)
13	October 8	Sterilizing straw
14	October 9	Dispersing mushroom spawn alternatively in straw and tighten in plastic bag with tiny holes around
15	October 10	Detailed reflection on mushroom farming procedure
16	October 11	STEAM project exhibition on art and craft work in addition to other STEAM projects

17	October 12	Evaluation and analysis of the work (Discussion with teachers and students)
18	October 13	Reflection sessions +Interview and discussion with the students and participants