



Teachers’ Views and Lived Experiences on Lifelong STEAM Learning in Philippine Higher Education

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ABSTRACT

This study explored how Filipino higher education STEAM (Science, Technology, Engineering, Agriculture, and Mathematics) educators interpret their lived experiences of lifelong STEAM learning. In-depth interviews were conducted with nine STEAM educators from public and private universities, with varying years of experience. Using Interpretative Phenomenological Analysis (IPA), the study revealed four overarching themes: (1) lifelong STEAM learning as a catalyst for individual competitiveness; (2) STEAM knowledge, skills, and attitudes as foundations for sustainable communities; (3) STEAM educators and scientists as drivers of creativity and innovation; and (4) advancing lifelong STEAM learning through collaborative synergies in Philippine higher education. The findings underscore the role of lifelong learning in fostering professional growth, innovation, and societal contribution. The study enriches the literature on lifelong STEAM learning and provides insights for policy development, resource allocation, and teacher professional development in higher education.

ARTICLE HISTORY

Editor-in-Chief:

Marie Paz E. Morales, PhD

Received:

October 13, 2025

Revised:

March 5, 2026

Accepted:

June 15, 2026

KEYWORDS:

interpretative; lifelong learning
phenomenology; STEAM teachers

Introduction

Teachers play a vital role in education, which is the foundation of lifelong learning and personal growth (Bolat & Kiyak, 2024; Shokhida, 2016). Regardless of the learning resources employed to support effective classroom pedagogies, teachers remain the most influential resource in the teaching and learning process (Hattie, 2009), as their lived experiences inform

pedagogical practices and enable authentic, context-responsive, and empathetic engagement with students. Similarly, these embodied experiences help illuminate what it means to be a teacher by shaping how teachers understand their roles, relate to learners, and navigate the complexities of classroom life. Du Plessis et al. (2014) affirmed that “teachers’ lived experiences in the classroom are the starting point of being a teacher” and that “the lived meaning of teaching defines teachers” (p. 1).

As described by Gadamer (1975), lived experience is a “significant whole” (p. 60) composed of significant parts or clusters of meaning (Du Plessis et al., 2014). Likewise, Given (2008) defined phenomenological experience as a representation of a person’s experiences and choices, as well as the knowledge gained from them. Furthermore, drawing on Vygotsky’s (1978) perspective that knowledge is co-constructed through social interaction and mediated by cultural tools, this study maintains that lifelong learning in Science, Technology, Engineering, Agriculture, and Mathematics (STEAM hereafter) occurs through dialogue, collaboration, and contextual engagement. Interdisciplinary integration, inquiry-based instruction, and collaborative design (Shabani, 2016) are therefore understood as socially mediated pedagogical processes that STEAM teachers enact as lifelong learners. The identified STEAM variables in this study are conceptualized as dynamic practices shaped by interaction, scaffolding, and professional meaning-making. This theoretical lens complements the study’s phenomenological grounding by situating STEAM teachers’ lived experiences within socially and culturally embedded educational contexts.

It is important to note that in this study, the term STEAM is used differently from its conventional usage in much of the international literature. While STEAM is commonly understood as the integration of Science, Technology, Engineering, Arts, and Mathematics, the present study adopts the Philippine higher education context in which STEAM refers to Science, Technology, Engineering, Agriculture, and Mathematics (Anito & Morales, 2019). Accordingly, the focus of this investigation is on educators teaching within these disciplinary domains rather than on STEAM as an arts-integrated instructional framework. This distinction is important for understanding the scope, context, and interpretation of the study findings.

Lifelong learning refers to the continuous, voluntary, and self-motivated pursuit of knowledge, skills, and competencies throughout an individual’s life for personal, professional, and social development (European Commission, 2001). Within the context of STEAM education, lifelong learning is particularly important given the rapid evolution of scientific knowledge, technological innovations, and interdisciplinary practices, which require educators to continually update their expertise.

As STEAM is a “significant driver of a country’s national economy and global competitiveness” (Anito & Morales, 2019, p. 2662), education for and lifelong learning in STEAM have become transnational concerns. Consequently, researchers and academics across Asia, Europe, Africa, and the Americas have devoted increasing attention to the issues and implications of STEAM education. While several Southeast Asian countries have increasingly

emphasized STEAM education and lifelong learning as key drivers of innovation and knowledge-based economic development, scholarly investigations specifically examining lifelong STEAM learning in the Philippine context remain limited. Existing Philippine STEAM scholarship has largely concentrated on teacher competencies, pedagogical models, assessment practices, and teacher professional development (Anito & Morales, 2019; Morales et al., 2020; Sarmiento et al., 2020). More recent studies have similarly emphasized teacher preparation and competency development in STEM education (de Vera et al., 2025). Internationally, contemporary STEAM research has focused on assessment frameworks (Cheng & Huang, 2025), teacher professional development and instructional beliefs (Mehddi et al., 2025), and innovative educational practices for future-ready learning (Ramírez-Montoya et al., 2025). While these studies have advanced understanding of STEAM education, comparatively limited attention has been devoted to exploring educators' lived experiences of lifelong learning within STEAM disciplines, particularly from a phenomenological perspective.

Drawing on these theoretical and empirical foundations, this interpretative phenomenological inquiry examines how Filipino higher education STEAM teachers make sense of their lived experiences of lifelong STEAM learning and construct professional meaning within Philippine higher education institutions (PH HEIs). My study is guided by the following central research question: How do Filipino STEAM teachers in higher education make sense of their lived experiences of lifelong STEAM learning? To address this question, the study explores three areas: (1) the meanings teachers attribute to lifelong STEAM learning; (2) their perceptions of the role of STEAM knowledge, skills, and attitudes in professional practice; and (3) their understanding of their roles, responsibilities, and challenges in advancing lifelong STEAM learning within Philippine higher education.

Methodology

Study Design

Interpretative Phenomenological Analysis (IPA) was used to describe, analyze, and understand the lived experiences and views about lifelong learning of Filipino STEAM teachers. Denovan and Macaskill (2012) emphasized that IPA is mainly concerned with an “*in-depth* exploration of an individual's lived experience of a phenomenon, its meanings for *the* individual and how the individual understands and makes sense of their personal and social environment” (p. 9). IPA enables an in-depth understanding of Filipino STEAM teachers' lived experiences of lifelong learning to emerge. Also, IPA was deemed appropriate in this study because of my interest in examining the commonness in the lived experiences of these STEAM teachers. It allowed me to explore, describe, and interpret how my participants made meaning of their experiences (Appiah-Twumasi et al., 2025; Martinez-Oquendo et al., 2022).

Participants

In this study, nine (9) STEAM teachers participated and shared their lived experiences as teachers, as scientists, and as lifelong learners themselves. They were between 45 and 60 years old; had varied teaching experience in SUCs and private HEIs; were ranked as either associate professors or full professors; and had published research papers in indexed journals. They hold a PhD in their field of specialization. Consistent with IPA methodology, the inclusion of 9 participants was considered appropriate to facilitate detailed idiographic analysis and in-depth interpretation of lived experience (Smith et al., 2009).

Sampling Procedure

The study participants were purposively selected based on criteria such as a full-time teaching assignment in the STEAM field, active involvement in STEAM research, publications and paper presentations, and engagement in lifelong learning activities. They were primarily selected for their extensive background in STEAM research and education.

Data Collection Instrument and Procedures

Data were gathered using a narrative interview protocol. A semi-structured interview schedule with open-ended questions was used to encourage free narrative responses and elaboration. Interviews were conducted in a private room in the university to ensure a relaxed, naturalistic setting. The participants were introduced to the study and were asked for their informed consent before the interview started. They were also informed that the whole process would be recorded, and the interview started as soon as they were ready. After the interview, participants were debriefed and informed about the main points discussed during the interview. These techniques are in keeping with the suggestions of Denovan and Macaskill (2013) and Smith et al. (2009).

Data Analysis

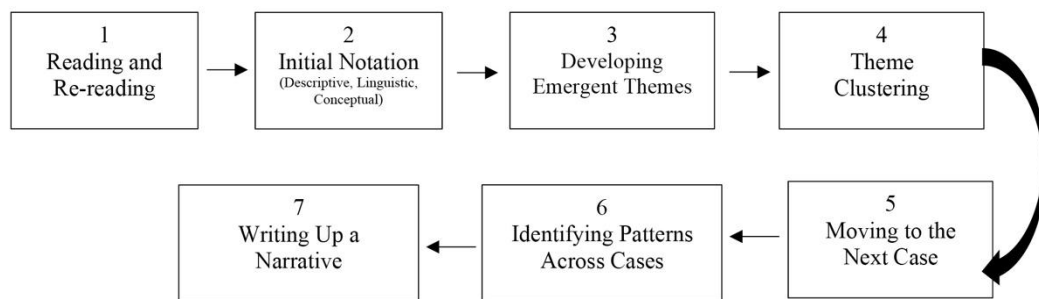
Gadamer's hermeneutic phenomenology and Vygotsky's sociocultural theory served as interpretative lenses for understanding participants' meaning-making processes and the social contexts shaping lifelong STEAM learning, while Interpretative Phenomenological Analysis (IPA) guided the analytical procedures. IPA was used to analyze the interviews following the methodology of Smith et al. (2009). Each of the nine interview transcripts was read and reread several times to gain a deeper understanding of the participant's experience. Initial notation was made on the interview transcripts to capture initial impressions and potential themes. In developing emergent themes, recurring patterns and ideas were identified within the data that capture the essence of the participant's experience. Additionally, interviews were analyzed to generate thematic reflections from participants' narratives. The units of analysis included words, phrases, sentences, and paragraphs from the interview transcripts. To avoid bias, I used the inductive approach to data analysis.

This study also used open coding to identify statements related to participants' lived experiences of lifelong learning. With this, I generated a total of 157 statements reflecting their lived experiences. Through constant comparison, the 157 statements were grouped into categories by clustering similar phrases and sentences into themes and categories, and were examined to identify connections and relationships among them. Moving to the next case, steps 1 to 4 in Figure 1 were repeated in all of the transcripts. Identifying patterns and variations across cases, I sought overarching themes that captured similarities and differences in my participants' lived experiences. To ensure the trustworthiness of the data, I enlisted coders not directly involved in the study to review the analysis and themes. Lastly, the reviewed data were reduced into final categories, synthesizing the findings and writing up a narrative that captures the essence of the lived experiences and their meaning for the participants. Data saturation was reached when no new themes or insights were generated, indicating that the phenomenon under study had been explored thoroughly from the participants' perspectives.

The interpretative phenomenological analysis (IPA) flow that guided this study is roughly diagrammed in the following steps:

Figure 1

The IPA Flow of the Study



Results and Discussion

Theme 1: Lifelong STEAM Learning as a Catalyst of Individual Competitiveness

After a thorough analysis of the narratives, the first theme that emerged was Lifelong STEAM learning as a catalyst of individual competitiveness (see appended Table 1). From this theme, two sub-themes emerged: 1) Skills and knowledge enhancement; and 2) Expanding opportunities. This theme is expounded through participants' views on lifelong STEAM learning as the pursuit of knowledge to enrich one's personal competitiveness and employability qualifications. This is suggested by the narratives of participants 1 and 3, who

framed lifelong learning as a means of enhancing skills and knowledge. For participant 7, lifelong STEAM learning is of overriding importance in this age of rapid scientific and technological advancement, so people need to develop and enhance their knowledge and skills in science and technology to stay relevant in this ever-changing world. This suggests that the scientific knowledge developed through lifelong STEAM learning may help individuals improve their well-being and expand their employment opportunities. Moreover, lifelong STEAM learning cultivates adaptability, problem-solving capabilities, and technological competencies, thereby strengthening individuals' capacity to respond effectively to the demands of an increasingly innovation-driven and digitally transformed workforce. Bolat and Kiyak (2024) averred that the necessity for adult and lifelong learning could be attributed to adaptation to an evolving era, among other factors. *"The more STEAM knowledge you have, the more opportunities you have."* Curtly, this is what participant 6 said about lifelong STEAM learning. Similarly, participant 9 described lifelong STEAM learning as a proactive way to gain competitiveness in the workplace.

As a whole, the participants' shared lived experiences revealed that lifelong STEAM learning is an integral part of human life and that everyone should take an interest in it, given its growing impact on people's daily lives. Filipino STEAM teachers in higher education uphold the insight that lifelong STEAM learning is imperative for personal competitiveness and skills enhancement, thereby expanding opportunities. As they shared their experiences, these STEAM teachers expressed that lifelong STEAM learning allows them to enhance their knowledge and skills, to create broader opportunities in their careers as STEAM professionals, and to enrich their personal competitiveness. Hence, lifelong STEAM learning demonstrates significant value and practical relevance in improving quality of life. This perspective is further supported by Billett (2023) emphasizing learning as a lifelong process that unfolds through participation in a wide range of experiences across work, education, and everyday life. Viewing learning from this broader perspective allows lifelong STEAM learning to be understood not simply as an educational outcome, but as an enduring disposition that supports individuals' ongoing development, adaptation, and engagement with society. Such learning contributes to navigating daily challenges and opportunities while also fostering the social and economic well-being of communities and nations. Similarly, Khatoon and Gewi (2025) stated that lifelong STEAM learning cultivates critical thinking, creativity, and digital competencies, significantly enhancing a person's personal competitiveness in today's innovation-driven global labor market.

Viewed through the lens of lifelong learning, the participants' narratives suggest that lifelong STEAM learning is not merely an avenue for acquiring new knowledge and skills but also a means of sustaining professional relevance in an increasingly knowledge-driven and technology-intensive society. In the Philippine higher education context, where rapid technological change and labor market demands continue to reshape professional expectations, participants perceived lifelong STEAM learning as a strategic resource for enhancing employability, adaptability, and career mobility. This finding extends existing literature by illustrating how Filipino STEAM educators themselves experience lifelong

learning as a pathway toward personal competitiveness and professional resilience, rather than solely as a mechanism for workforce development (Bolat & Kiyak, 2024; Dierking, 2007; Khatoon & Gewi, 2025).

Theme 2: STEAM Knowledge, Skills, and Attitudes (KSAs) as Foundations for Building Sustainable Communities

Another theme that emerged from participants' lived experiences is that STEAM knowledge, skills, and attitudes (KSAs) are foundational to building sustainable communities.

Participant 1 perceived science-related knowledge as important in safeguarding a sustainable community. A similar perception is held by participant 8, who said that STEAM KSAs play an important role in addressing environmental issues and ensuring a balanced community. As reflected in the lived experiences of participants 1 and 8, scientific knowledge and attitudes play important roles in understanding environmental problems and in applying practical solutions that help maintain a balanced community. Their perception also suggests that, in general, STEAM knowledge, skills, and attitudes are important for advancing understanding of human-environment interactions and systems, and of how these interactions affect the challenge of sustainability. Meanwhile, participant 3 perceived that the use of STEAM knowledge is highly effective in addressing the complexity of the challenges the world faces, particularly in ensuring a sustainable and resilient community.

In a different light, participant 6 perceived that KSAs in science cultivate collaboration that fosters innovation, resource sharing, and accountability, which are necessary for building a sustainable community that unhesitatingly captures opportunities and promptly responds to challenges. With KSAs in science, people in sustainable communities can promote a culture of proactive problem-solving that provides access to previously unattainable opportunities and supports the risk-taking necessary for growth and innovation (Mitchell & Walinga, 2017).

Still on STEAM KSAs, participant 7 proposed to make use of STEAM knowledge and skills, as well as a scientific attitude, to survive the fourth industrial revolution and to effectively manage the changes that may be brought about by it as these changes will surely impact the life of every individual and the community in general. The last part of the narrative, in which participant 7 advocated continuous engagement in discovery, re-discovery, inventions, and innovations, implies continuous development, an attribute of a sustainable community.

Participant 2 emphasized that STEAM knowledge, skills, and attitudes (KSAs) contribute to the development of resilient and sustainable communities. Community resilience refers to the ability of individuals and groups to adapt to, respond to, and recover from challenges and adverse conditions. Through her research, Participant 2 generated and disseminated agricultural knowledge that informed farmers about appropriate crop varieties for cultivation. This enabled them to make more informed farming decisions and increased the likelihood of achieving favorable harvest outcomes. Her account further suggests that STEAM

KSAs, particularly scientific knowledge in agriculture, empower community members to think and act systematically. Such systems-oriented thinking is widely recognized as a key characteristic of sustainable communities. Consequently, STEAM KSAs foster a systems perspective among community members, strengthening their capacity to build and sustain resilient and sustainable communities.

Similarly, participant 5 focused on community sustainability when he shared his insights about STEAM knowledge, skills, and attitudes. He said that being results-oriented is one of the implications of applying STEAM KSAs, or scientific knowledge. It can be seen from participant 5's perspective that scientific knowledge contributes significantly to achieving goals or results. As being results-oriented is a feature of a sustainable community, it can be said that STEAM KSAs are a factor in building a sustainable community that is propelled and inspired by leadership through action and results.

In summary, participants' views and perspectives on STEAM KSAs reveal that lifelong STEAM learning plays an important role in building sustainable communities. The meaning that can be construed from the lived experiences of the study participants is that people learn STEAM, enhance their skills, and develop attitudes in lifelong STEAM learning for their work, for living, and for their community involvement, hence, ensuring sustainable communities characterized by collaboration, invention and re-discovery, innovation, resiliency, and results-oriented leadership. Regarding collaboration, Ejiwale (2014) suggested that it plays a major role in interdisciplinary activities across STEM disciplines. More specifically, collaboration has the obvious role of bringing talents together for a common purpose: combining knowledge and sharing responsibility, creativity, and others' experience. Facilitating collaboration is very important as it provides a strong foundation for building a sustainable community.

Collectively, these narratives reveal that participants conceptualize STEAM KSAs not only as individual competencies but also as resources for community transformation and sustainability. This perspective reflects the Philippine context, where communities frequently confront environmental, agricultural, technological, and socioeconomic challenges requiring locally relevant and science-informed solutions. The findings, therefore, extend existing discussions of lifelong STEAM learning by highlighting its perceived social and civic value. Rather than viewing it solely as preparation for employment or economic productivity, participants emphasized the role of lifelong STEAM learning in fostering resilient, collaborative, and sustainable communities that can respond to complex societal challenges.

Theme 3: STEAM Teachers and Scientists as Vanguard of Creativity and Innovation

The third theme, arising from the participants' phenomenological views, concerns the roles and responsibilities of STEAM teachers and scientists. The participants' narratives reflect the theme that STEAM teachers and scientists are the vanguard of creativity and innovation.

For participant 1, STEAM teachers and scientists are frontrunners in invention and innovation. To this end, participant 1 implied that, in general, STEAM scientists and teachers should take the lead in building a knowledge-based economy and be able to stimulate the country's economic growth. Likewise, it can be deduced from participant 1's experience that the academe also plays a pivotal role in achieving economic growth and development through the commercialization of research outputs produced at universities. The knowledge, inventions, and innovations produced by STEAM scientists must be used to achieve a competitive advantage. In some countries, a knowledge-based economy is related to higher education and research and the strategic role of university-business collaboration (Moid et al., 2024), hence, the significant role of STEAM scientists and teachers in the construction and development of a knowledge-based economy.

Similarly, participant 2 stated that STEAM scientists and teachers are tasked with spearheading the country's efforts in scientific discovery, creativity, and innovation. Referring to her research outputs, she mentioned that it is important to utilize research outputs so that the target end-users benefit from the research conducted by the STEAM teachers and scientists. Hence, the diffusion and transfer of technology developed by STEAM teachers and scientists must be carried out to ensure that scientific and technological developments are accessible to a wide range of users and beneficiaries. To this end, STEAM teachers and scientists should always be at the forefront of creativity and innovation.

For participant 3, however, the primary role of STEAM scientists and teachers is to provide new information and develop new technology based on their research, suggesting that research dissemination is a basic function of STEAM scientists. It means that their inventions and innovations, when disseminated within the community, become significant because the public benefits from them, thereby encouraging community development and improvement.

Participant 7 expressed a similar perspective, emphasizing that STEAM researchers and scientists have a fundamental responsibility to disseminate their research findings to local communities and promote technology transfer to ensure that scientific knowledge remains relevant and beneficial to the public. This experience highlights the important role of STEAM professionals as drivers of creativity and innovation. Furthermore, their contributions help strengthen national competitiveness by supporting socioeconomic advancement and industrial development. Through scientific discoveries and technological innovations, Filipino STEAM practitioners have made meaningful contributions to the country's progress and to improving citizens' quality of life.

Participant 8's experience underscores the need to advance research initiatives, strengthen support and investment in research and development, promote technological innovation, and harness science to address socioeconomic challenges and pressing issues such as climate change and disaster risk. These strategies have been widely adopted in many nations, particularly those with advanced levels of development. Applying similar efforts in

the Philippine context could help accelerate the country's progress across socioeconomic, technological, and other developmental dimensions, enabling it to become more competitive with both highly developed nations and neighboring countries in Asia. In pursuing these goals, scientists continue to play a pivotal role in national development and innovation, underscoring the indispensable value of lifelong STEAM learning in sustaining their contributions.

Participant 9 likewise highlighted the significant role of STEAM researchers and scientists in advancing research and development, fostering creativity, and driving innovation. His experience underscores the importance of STEAM professionals in ensuring that scientific knowledge and technological advancements contribute meaningfully to addressing pressing societal challenges, including climate change, disaster risk reduction, health concerns, food security, energy sustainability, and emerging technologies such as artificial intelligence. Furthermore, his account suggests that Filipino STEAM researchers and scientists must continually engage in lifelong STEAM learning to enhance their knowledge and expertise to keep pace with the rapid advancements in science and technology occurring both regionally and globally.

All told, the participants' lived experiences as STEAM teachers and scientists point to the theme that STEAM scientists and teachers are the vanguard of creativity and innovation. It implies that these STEAM scientists play influential roles in the country's knowledge-based economy. They serve as key drivers to development, and they help ensure the country's "sustainable competitiveness and long run growth" (Sener & Saridogan, 2011, p. 815). This meaning is reinforced by Rothwell (2013), who averred that the role of workers in STEM fields is highly precise in driving economic growth, as their innovations and inventive activities have become a fundamental source of economic progress. Moreover, Perales and Arostegui (2021) suggested that STEAM education influences innovation, workforce adaptability, and long-term economic growth; hence, STEAM contributes to societal advancement and labor market impact. These ideas can also be gleaned from the lived experiences of STEAM teachers and scientists who shared their narratives in this phenomenological study.

The experiences shared by the participants underscore the perceived responsibility of Filipino STEAM educators and scientists to contribute directly to national development through research, innovation, and knowledge dissemination. Their narratives reflect broader aspirations to strengthen the Philippines' research, innovation, and technology ecosystems despite persistent constraints in funding and institutional support. In this regard, the findings contribute to existing literature by demonstrating how Filipino STEAM educators understand their professional identities not only as teachers but also as innovators, knowledge producers, and agents of socioeconomic development. This interpretation expands current discussions of lifelong STEAM learning by emphasizing educators' lived experiences as contributors to a knowledge-based economy.

Theme 4: Advancing STEAM Lifelong Learning through Synergies

The fourth theme extracted from the participants' lived experiences concerns the issues and challenges they encounter as STEAM teachers and researchers. Regarding the challenges Filipino STEAM teachers encounter, the participants are unanimous in saying that the biggest challenge they face as STEAM researchers is the apparent lack of government funding and support for research and development. This has been mentioned by participants 7 and 8. Participant 3 further lamented the stringent government regulations. Participant 3's experience makes it clear that STEAM teachers and researchers in the country face challenges that affect research and development, as well as the teaching and learning of STEAM in higher education. Participant 3 is of the idea that working together – the academe, industry, and relevant stakeholders – could help address the belief gap or the misconception that graduates of Agriculture programs are not employable in the country, or the belief that only a few industries hire graduates in this field of study. Perhaps this could be addressed by increasing the awareness of students in the basic education about agriculture as a field of study in college and as a field of profession, and by strengthening and constantly updating the program at the pace demanded by the industry.

Additionally, participant 1 stated that students enrolled in the BS in Agriculture programs seem to be challenged by the job opportunities available to them in the country, as there are few industries that would hire them after graduation. This is, according to participant 1, why students enrolled in Agriculture programs view the course as an avenue to work abroad. Participant 4 suggested that modern technologies could be used in the teaching and learning of Agriculture and STEM courses in state universities and colleges.

Participant 6 mentioned the need to enhance students' OJT (on-the-job training). Perhaps this is so because students can practically apply what they have learned in the classrooms when they are sent off to their on-the-job trainings, practicum, or apprenticeship programs. This is one way of learning by experience, where learners gain hands-on, practical experience. This implies that what students learn in the classroom must be complemented by what they learn from their practicum, OJT, or apprenticeship programs.

Similarly, for participant 5, the lack of technological resources is the number one challenge he faces in the teaching and learning of Engineering. He emphasized the importance of modern technological learning resources, adequate learning facilities, and practical content in the teaching and learning process to ensure that the learning outcomes of Engineering students are not compromised. He suggested that when all of these elements are in place, students will not only learn the fundamental knowledge and skills of an engineer but also the necessary attitude for lifelong learning, which will help them become globally competitive Filipino engineers.

Moving on, participant 7 shared that the lack of training opportunities for the professional development of IT educators is a major challenge for her and most IT educators in the country today. Participant 7 pointed out that the relevant training for IT educators is

so important that they would not be certified in a given qualification or skill without it. IT educators need such training so they can effectively integrate specific new technologies into their lessons and teaching methods, making the teaching-learning process more engaging for students. Likewise, training is one way to ensure that IT educators stay current with rapidly evolving technologies, pedagogies, and industry standards. Continuing professional development for IT educators equips them with the skills necessary to deliver complex technical content, integrate innovative tools into the classroom, and foster lifelong STEAM learning in a dynamic digital landscape.

In a similar vein, participant 8 expressed the need to train science teachers in new pedagogies that integrate technology, such as AI, so that students have meaningful learning experiences in the classroom and even outside it through informal learning. Participant 8 also emphasized the use of technology in science teaching and learning. It was also suggested that science teachers should undergo training to develop the necessary knowledge and skills to integrate technology into science teaching. It has been said that aside from content knowledge, “having adequate pedagogical knowledge allows teachers to teach a particular science concept to a particular group of students” (Guzey & Roehrig, 2009, pp. 21-23). In addition to content and pedagogical competencies, STEAM teachers must also develop strong technological knowledge and skills through active lifelong STEAM learning. Effective integration of technology into teaching practices enables educators to support students in building and deepening their understanding of the content. A wide range of technologies can be integrated into contemporary STEAM classrooms, including digital microscopes, sensor-based data collection systems, simulation and modeling software, robotics platforms, artificial intelligence applications, virtual and augmented reality tools, and other emerging digital technologies that support inquiry, experimentation, and problem-solving. To maximize the educational potential of these technologies, however, STEAM teachers require adequate professional development and training not only in their operation but also in the pedagogical integration of advanced technological tools that can enrich students’ learning experiences (Herro et al., 2018; Leavy et al., 2022).

Similarly, participant 9 opined that the teaching and learning of science requires a concerted effort by science teachers to create an active learning environment that encourages independent inquiry and problem-based learning. Teachers also need to facilitate a classroom social environment where students actively work in social groups and cooperatively. There is also a need for STEAM teachers to ensure active student engagement by making sure students are aware of the clear connection between what they learn and their personal interests and goals, so that learning STEAM becomes more meaningful for them (Anito & Morales, 2019). Lastly, participant 9 mentioned that appropriate pedagogy and tools are necessary to ensure that independent and problem-based inquiry approaches are used in class to develop lifelong interests in science.

As a whole, participants are saying in their narratives that despite the challenges that they encounter in delivering STEAM learning to their students, they perceive that lifelong STEAM learning could be advanced and be made more progressive through a synergy of a host

of essentials such as collaboration among the academe, industry, and relevant stakeholders, modern technological learning resources, adequate learning facilities, and practical content in the teaching and learning process, and relevant trainings of teachers on pedagogies and technology integration to create 21st century STEAM classrooms characterized by an active learning environment where independent inquiry and problem-based learning are encouraged to develop lifelong interests in STEAM.

Importantly, the challenges identified by the participants illuminate structural and institutional conditions that shape the delivery of STEAM education in Philippine higher education. Issues related to funding, technological resources, professional development opportunities, and industry engagement suggest that advancing lifelong STEAM learning requires systemic rather than purely individual responses. The participants' emphasis on collaboration among the academe, industry, government, and other stakeholders points to the importance of collective action in strengthening STEAM education. This finding contributes to the literature by identifying the contextual factors that influence educators' experiences of lifelong STEAM learning and by highlighting the need for sustained institutional support to foster innovation and professional growth.

Taken together, the four themes portray lifelong STEAM learning as a multidimensional phenomenon that encompasses personal competitiveness, community sustainability, innovation, and collaborative engagement. Consistent with Gadamer's view of lived experience as a source of meaning, participants interpreted lifelong STEAM learning through their professional journeys and experiences as educators and researchers. Likewise, the findings resonate with Vygotsky's sociocultural perspective by illustrating how learning, innovation, and professional growth are shaped through social interaction, collaboration, and participation within educational and professional communities. Collectively, the findings contribute to the growing literature on lifelong STEAM learning by providing a contextualized account of how Filipino higher education STEAM educators make sense of their experiences and responsibilities within a rapidly evolving educational and technological landscape.

In summary, a thematic map of the four superordinate themes and sub-themes is presented as Figure 2 in the appendix. The thematic map comprises four superordinate themes: (1) lifelong STEAM learning as a catalyst of individual competitiveness; (2) STEAM knowledge, skills, and attitudes (KSAs) as foundations for sustainable communities; (3) STEAM teachers and scientists as vanguards of creativity and innovation; and (4) advancing lifelong STEAM learning through synergies in Philippine higher education. Theme 1 encompasses the sub-themes of skills and knowledge enhancement, employability enrichment, opportunity expansion, and self-sustainability. Theme 2 includes capacitated communities, human–environment interactions and systems, practical solutions, accountability, and resource sharing. Theme 3 comprises knowledge-based economic development, socioeconomic progress, and industrialization, all anchored in discoveries, inventions, innovations, emerging technologies, and the Fourth Industrial Revolution. Theme 4 comprises academe–industry–stakeholder collaborations, the classroom social environment, STEAM pedagogies, practical content, technological resources, and technology integration.

Conclusion and Recommendations

This study explored the views and lived experiences of Filipino STEAM teachers in Philippine higher education institutions (PH HEIs) regarding lifelong STEAM learning. Specifically, it sought to understand how Filipino STEAM teachers make sense of their lived experiences of lifelong STEAM learning, the meanings they attribute to lifelong STEAM learning, their perceptions of STEAM knowledge, skills, and attitudes (KSAs), and their understanding of their roles, responsibilities, and challenges in advancing STEAM learning.

The findings suggest that Filipino STEAM teachers understand lifelong STEAM learning as a continuous process of professional growth, knowledge development, innovation, and community engagement. Participants viewed lifelong STEAM learning as essential for maintaining competitiveness, enhancing STEAM knowledge, skills, and attitudes, contributing to sustainable communities, and fulfilling their roles as educators, researchers, and innovators. At the same time, their experiences revealed the importance of collaborative partnerships, institutional support, professional development opportunities, and access to technological resources in advancing lifelong STEAM learning within Philippine higher education.

The findings contribute significantly to the emerging discourse on lifelong STEAM learning by addressing persistent gaps in the literature concerning teachers' lived pedagogical experiences. While previous studies have frequently emphasized student outcomes, curriculum implementation, assessment practices, and program effectiveness, limited attention has been devoted to understanding how STEAM teachers in PH HEIs construct, enact, and sustain lifelong learning throughout their professional lives. By foregrounding teachers' meaning-making processes and sustained engagement with STEAM learning, this study advances a more nuanced understanding of lifelong STEAM learning as a dynamic, socially mediated, and professionally evolving process.

The phenomenological views of Filipino STEAM teachers suggest that lifelong STEAM learning can be understood as the continuous development and enhancement of individuals' STEAM potential through supportive, enabling learning processes. Such processes encourage the acquisition of knowledge, skills, attitudes, and understanding necessary for becoming productive STEAM-literate citizens and professionals. One major theoretical implication of this finding is that STEAM learning should be conceptualized as a lifelong developmental continuum rather than a stage-bound instructional outcome. This perspective reframes STEAM not merely as interdisciplinary instruction but as an evolving process of identity formation, creativity, innovation, and problem-solving that unfolds throughout the lifespan.

The findings further reveal that STEAM KSAs are perceived as fundamental resources for building resilient and sustainable communities. Participants associated STEAM competencies with collaboration, innovation, environmental stewardship, resilience, and

community development. The theoretical implication is that lifelong STEAM learning contributes not only to individual advancement but also to broader societal sustainability and community well-being.

The experiential accounts of the participants likewise demonstrate that STEAM teachers and researchers in Philippine higher education play important roles in advancing the country's knowledge-based economy. Their discoveries, innovations, and research outputs contribute to scientific advancement, technological development, and socioeconomic progress. As vanguards of creativity and innovation, STEAM educators and scientists are well-positioned to address pressing national concerns in health, food security, environmental sustainability, technological development, and economic growth.

The findings also indicate that advancing lifelong STEAM learning requires developing synergistic relationships among higher education institutions, industry partners, government agencies, and other relevant stakeholders. Participants emphasized the importance of innovative pedagogies, technology integration, adequate learning resources, supportive classroom environments, and continuing professional development opportunities. These findings suggest that sustained collaboration and institutional support are essential for creating dynamic pathways for lifelong STEAM learning and innovation.

Based on these findings, it is recommended that higher education institutions strengthen professional development initiatives that enable STEAM educators to continuously update their disciplinary knowledge, pedagogical competencies, and technological skills. Policymakers and institutional leaders should likewise invest in research support, technological infrastructure, and innovation-oriented learning environments that facilitate lifelong STEAM learning. Stronger partnerships among the academe, industry, government, and community sectors should also be cultivated to enhance knowledge transfer, research utilization, and workforce development. Such initiatives may help bridge the gap between theoretical knowledge and real-world application while strengthening STEAM education's contribution to national development.

This study should also be interpreted in light of its limitations. While the qualitative and interpretative nature of the inquiry enabled an in-depth exploration of participants' lived experiences, the findings are not intended for statistical generalization. Future research may address this limitation by employing mixed-methods or quantitative approaches to examine the transferability of the emergent themes across broader contexts and populations.

For future research, longitudinal studies may be conducted to examine how individuals in STEAM fields construct personal, professional, and creative meaning from lifelong learning over time. Further investigations into the lived experiences of STEAM professionals in digital learning environments may also provide deeper insights into meaning-making processes within virtual contexts. Finally, future IPA studies may explore lifelong STEAM learning among cross-sector participants across education, industry,

government, and community settings to further illuminate the diverse ways in which it is experienced and sustained.

Study Limitations and Reflexivity

This study should be interpreted in light of several limitations. First, the findings are based on a small purposively selected sample of nine Filipino STEAM educators and are therefore intended to provide depth of understanding rather than statistical generalizability. Second, participants were drawn from specific higher education contexts, and their experiences may not reflect those of all STEAM educators in the Philippines. Finally, as an interpretative phenomenological inquiry, the findings represent co-constructed interpretations of participants' narratives and should be understood within the particular social and institutional contexts in which the study was conducted.

As the researcher, I acknowledge that my professional interest in lifelong learning and STEAM education informed the conduct and interpretation of this study. Consistent with the principles of Interpretative Phenomenological Analysis, I engaged in ongoing reflexive practice throughout data collection and analysis by maintaining analytic memos, critically examining personal assumptions, and remaining attentive to participants' meanings as expressed in their narratives. These practices were undertaken to enhance transparency and interpretative rigor.



Statements and Declarations

1. **Funding details.** This paper is a component of a research program funded by the Commission on Higher Education.
2. **Disclosure statement.** There are no competing interests to declare.
3. **Acknowledgment:** The author extends his gratitude and thanks to the following research/technical experts: Dr. Wilma S. Reyes and Prof. Elanor C. Bayten of the Philippine Normal University; Dr. Belinda A. Tad-awan of Benguet State University; and Dr. Emma K. Sales of the University of Southern Mindanao.
4. **Ethical Approval:** This research was approved by the MSEUF University Research Ethics Committee. Code: MSEUF-Faculty-008-2023.
5. **Declaration of Generative AI in Scientific Writing**
Thematic map was enhanced using ChatGPT.

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Bionote

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Appendix

Table 1

Filipino STEAM Teachers' Meaning-Making of Lifelong STEAM Learning

Superordinate Theme	Sub-theme	Verbatim Extract (Participant Quote)
Lifelong STEAM learning is a driver for enhancing personal competitiveness.	Skills and knowledge enhancement	Lifelong learning is learning for enhancement of our capability... for us to enrich qualifications and also to be more responsive to the demands of our profession. (Participant1) I have to refresh and learn again or re-learn. I need to enrich whatever skills and knowledge that I have. And I think that's lifelong learning... you don't stop learning (Participant 3) Learning must continue so that we are able to enhance our knowledge and skills to cope with the changing times. <i>Kelangan natin mag-upgrade and upskill</i> [We need to upgrade and upskill.] (Participant7)
	Expanding opportunities	The more STEAM knowledge you have, the more opportunities you have. (Participant 6) It gives us opportunity to learn new things, new skills... whether formal or informal learning. (Participant 5) Lifelong STEAM learning provides us opportunities to be more competitive in the workplace. (Participant9)
STEAM Knowledge, Skills, and Attitudes ensure sustainable communities.	Relevance of scientific knowledge in a sustainable community	I always say that we need scientific knowledge in order to maintain a balanced community. We need science to tackle complex challenges for humanity such as climate change, biodiversity loss, pollution and poverty reduction, among others. (Participant 1) I always tell my students the value of scientific knowledge in solving practical problems, most especially those that have to do with environmental issues...the community... how to achieve a balanced community. (Participant 8) I tell my students that STEAM knowledge can be used in protecting our environment while we benefit from it. (Participant 3)
	Working together for a sustainable community	so with our KSAs in science, we.. we collaborate... collaboration... that's very important in a sustainable community...(Participant 6)
	Integrating discovery, re-discovery, and IR 4.0 to foster sustainable communities	And with our scientific KSAs, as you call it, we must be continuously engaged in discovery, re-discovery... in inventions... and innovations as we endure the impact of the changes brought about by IR 4.0 in our lives...(Participant 7)
	Strengthening citizen capacities for sustainable community development	My field is agriculture. You know farmers are very resilient... pliant. In fact, after every storm... when their crops have been devastated, they'll plant again... and with every knowledge that they have of agriculture, I could say that they are able to make their life a little easier for them to face. (Participant 2)
	Adopting results-driven mindset for sustainable community development	We become more results-oriented when we use or apply systematic thinking. That's actually what STEAM KSAs are all about. (Participant 5)

STEAM teachers and scientists are vanguards of creativity and innovation.	Construction of a knowledge-based economy	In a knowledge-based economy, scientists play a very significant role in creating opportunities to effect changes brought about by science and technology. We must always be at the front line in advancing the economy of the country. Our inventions and innovations must be able to uplift our economy. (Participant 1)
	STEAM teachers driving invention and innovation	Yeah, these outputs had already been transferred to the different farmers all over the Philippines. Like for example my rubber... the diagnostic kit that I have developed. We are now applying it because many nursery owners are sending their samples or their planting materials to us for identification. (Participant 2)
	STEAM teachers as creator of new technology	Primarily, scientists should provide new information and new technology that could be shared to the community. (Participant 3)
	STEAM teachers at the forefront of discovery	Conferences and publications are important avenues for scientists to share their discoveries. It's not only through commercializing or diffusing them (to the community). When we do that, we put ourselves at the forefront of discovery. (Participant 7)
	STEAM teachers as producers of knowledge and leaders of innovation	I agree that Filipino STEAM scientists, as what you call them, should lead this country to greater development. We should be the leaders in generating new knowledge and fostering innovation that would help the country with its development. (Participant 9)
	The role of STEAM teachers in societal and economic development	We should emphasize the role of science and technology in business... and in other relevant issues in our daily life like climate change and disaster. S&T has had a great influence in the development of the country. (Participant 8)
	Global competitiveness of Filipino STEAM teachers	We must work hard in order to be at pace with the development of science and technology in the region and the neighboring countries specifically, and the world in general. Personally, I believe that our scientists have so many success stories to tell. (Participant 9)
Lifelong STEAM learning thrives through meaningful synergies.	Synergy in addressing resource gap and financial constraints in STEAM education	I think the biggest challenge in the advancement of STEAM is the limited funding and inadequate resource allocation for STEAM research by the government. (Participant 7) Lack of funding for STEAM education and research. It restricts opportunities for discovery, collaboration, and the development of solutions to real world problem. (Participant 8).
	Synergizing policy and practice for the advancement of STEAM education.	Lack of harmonization among government agencies policy and practice is one challenge. That's really the biggest challenge I'm facing nowadays. (Participant 3) The academe, the industry, and other stakeholders should work together so that the belief of students that Agriculture graduates are not employable in the country... this mind-set (of the students) could be changed and motivate them to engage themselves in lifelong learning in Agriculture (Participant 3)
	Collaborative approaches to transforming mindsets of agriculture graduates through STEAM education	Sometimes they enroll in Agriculture because they think it will help them get a job abroad... maybe because they see that there's very limited demand of the industry for Agriculture graduates in the Philippines. (Participant 1)

Synergy in addressing technological limitations and reframing OJT programs in STEAM for quality learning outcomes

Another challenge we have is the unavailability of latest technologies in Agriculture that we could use in teaching. We really lack those agriculture engineering technologies in our country. (Participant 4)

I think there's a need also for other SUCs to collaborate with the industry for the OJT of our students. OJT programs for STEAM courses have to be enhanced. (Participant 6)

If there's one challenge that I face in teaching Engineering courses, well... I think it's the lack of technological resources that can be used in the teaching-learning process. (Participant 5)

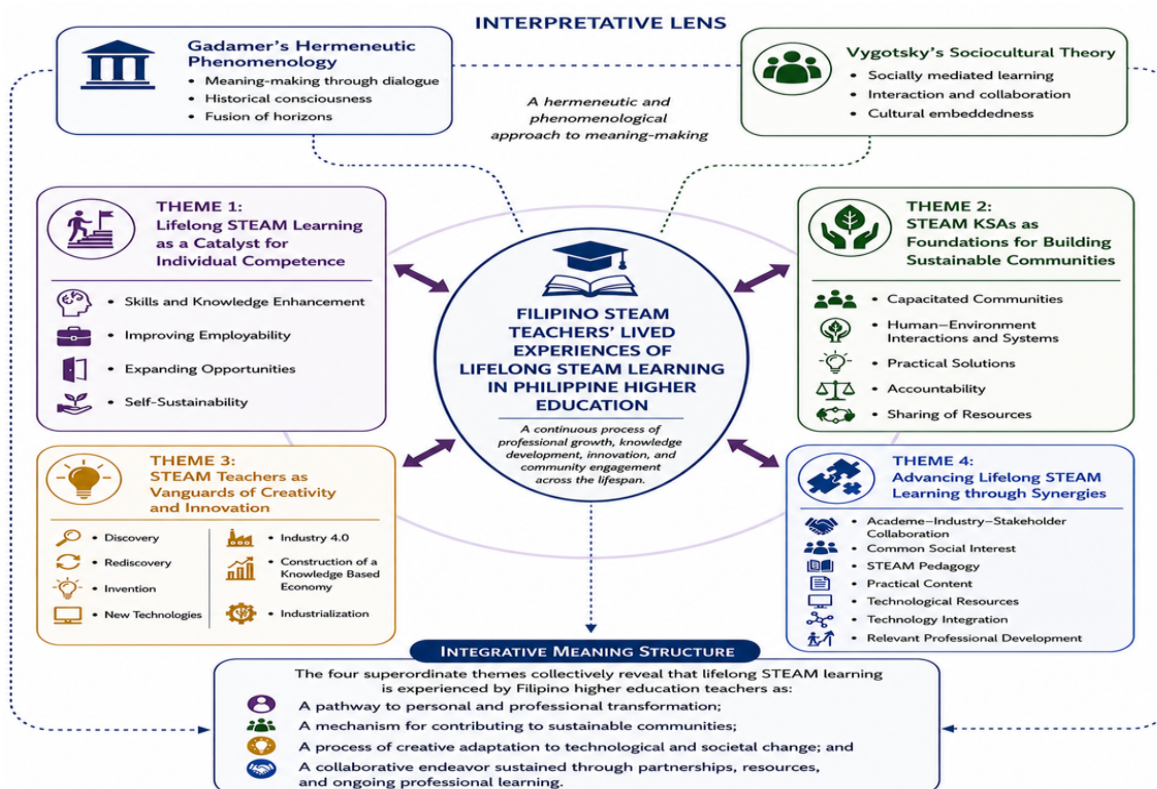
I guess it's the apparent lack of training opportunities for us educators in the field of IT education. (Participant 7)

Students will become lifelong learners in science if we use more technologies in our classes or a combination of traditional and technology-oriented pedagogies like the use of AI. But technology-oriented pedagogies will require that science teachers undergo training or if possible, certification on this. But sadly, not too many training opportunities on this thing are available in the country unlike in Singapore or in Canada. (Participant)

One of my biggest challenges as a science teacher is on how to promote active engagement among my students in my science classes... you know.. creating a learning environment that is actively engaging... one that promotes independent inquiry...ahmm.. problem-based learning. (Participant)

Figure 2

Thematic Map Illustrating Filipino STEAM Teachers' Lived Experiences of Lifelong STEAM Learning in Philippine Higher Education



The model shows the four superordinate themes, their associated subthemes, and the broader personal, community, and societal outcomes emerging from participants' narratives.

Table 2

Study Participants' Profile

Participant	Discipline	Institution Type	Years of Teaching	Highest Qualification
P1	Mathematics	Public HEI	28	PhD
P2	Agriculture	Public HEI	35	PhD
P3	Agriculture	Public HEI	31	PhD
P4	Mathematics	Public HEI	23	PhD
P5	Civil Engineering	Private HEI	21	PhD
P6	Science - Physics	Public HEI	23	PhD
P7	Information Technology	Private HEI	21	PhD
P8	Chemical Engineering	Private HEI	27	PhD
P9	Science- Biology	Private HEI	37	PhD

Framework

Gadamer's hermeneutic phenomenology and Vygotsky's sociocultural theory informed the interpretation of participants' narratives rather than serving as predetermined coding frameworks. Gadamer's conception of lived experience as a source of meaning guided the interpretative examination of how participants understood and reflected upon their lifelong STEAM learning journeys. Concurrently, Vygotsky's sociocultural perspective provided a lens for understanding how these experiences were shaped through social interaction, collaboration, professional engagement, and participation in educational communities. Accordingly, emergent themes were interpreted in relation to both participants' meaning-making processes and the social contexts within which lifelong STEAM learning occurred.