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The Road Not Taken: A Narrative Inquiry of Science Appreciation among Non-STEM Students

by

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Abstract

This study was conducted to explore the science appreciation journeys of non-STEM students. Specifically, this study focused on how the participants' significant life experiences led to their science appreciation and influenced their decision not to take a STEM track despite their science appreciation. Moreover, this research also explored how their experiences as non-STEM students shape their plans in the future and what reflections we can have on their stories of science appreciation as an unpursued path. The study followed the narrative inquiry design of the qualitative research method. An interview guide, aligned with the research sub-questions and validated by an expert, was used to collect the participants' narratives and stories, which helped answer the study's central question. Also, the researcher followed the research protocols to protect human subjects. The study's trustworthiness was managed, so the results became confirmable, transferrable, dependable, and credible. Since this study explored the science appreciation journeys of purposefully selected non-STEM students, nonprobability sampling, purposeful sampling, and criterion sampling were used because these were the most suitable sampling techniques and allowed the researcher to gain insights and learn about the phenomenon. The population being studied comprised non-STEM students in Metro Manila. The main criterion for the sampling was the participant should have shown science appreciation and be currently enrolled in a non-STEM strand or track in the Senior High School. The study found that the participants' appreciation of science through intra-curricular and extra-curricular experiences through practical science applications. Also, family, peers, and resources are the main factors influencing the participants' decision not to pursue a STEM strand. Thus, having scientific discussions, motivation to pursue a dream college course, and science-related tasks in a non-STEM environment contribute to participants' shaping plans. Moreover, participants still possess science appreciation even though they did not pursue a STEM strand because they have scientific values that they can apply to conserve the environment. Furthermore, this study recommends providing learning opportunities where students can still exercise their interests in science. In addition, assisting learners on which path to take, either science or non-science-related, through career exploration programs is essential. Similarly, with parental involvement, intensifying career guidance programs to ensure learners have the liberty to decide their future must be done. Furthermore, future researchers are encouraged to make parallel studies focusing on the limitations of this study.

Keywords: Appreciation of science, Narrative inquiry, qualitative research, non-STEM learners

INTRODUCTION

'Science Appreciation' is described as recognizing the significance of scientific excellence and deciding the scientific explanation between the conflicting thinking methods (Mugaloglu & Erduran, 2014). Accordingly, the students' experiences can give them first-hand familiarity and build a sense of science appreciation in teaching and learning. Learners participating in science practices better understand how scientific knowledge is created (Jebalin Paul & Mini Kumari, 2020).

As years went by, students' motivation levels declined at some point. A survey asked American students, and most did not like to pursue STEM because it is too hard for them compared to non-STEM courses. Moreover, those students interested in STEM courses but did not follow them due to the following reasons: cost and time barriers, personal or family circumstances, and finding another field of interest and going a different path (Kennedy, Hefferon, & Funk, 2018). For these reasons, it is noteworthy that the education system should provide subsidies for deserving students who wish to take STEM-related courses but cannot afford them (Ononye & Bong, 2018).

On the contrary, experts in the Philippines claim that students' interest in pursuing STEM-related courses has become evident since the start of the K to 12 program. One of the reasons they saw is the increase in priority to STEM jobs (Uğraş, 2018). As Jebalin Paul and Mini Kumari (2020) explained, one of the ways to foster science appreciation among students is through the workforce and the teachers. Teachers must ensure students' awareness of science's influence on humanity's benefit. The teacher must explain the explorations of scientists in searching for truth to facilitate the students to appreciate the contribution of scientists.

Despite the studies made to investigate science appreciation among STEM students and professionals, no significant local and international study was done to investigate science appreciation among non-STEM Senior High School students. Furthermore, this study is not limited to non-STEM students but chose other Academic track-related strands; it also includes those who chose non-Academic tracks such as Technical-Vocational-Livelihood, Sports, and Arts and Design tracks. Therefore, this study aims to examine science appreciation among non-STEM SHS students and understand how their significant life experiences contribute to their liking of science.

Statement of the Problem

The study aimed to explore the science appreciation journeys of non-STEM students. Specifically, this study focused on how the participants' significant life experiences led to their science appreciation and influenced their decision not to take a STEM track despite their science appreciation. Moreover, this research also explored how their experiences as non-STEM students shape their plans for the future and what reflections we can have on their stories of science appreciation as an unpursued path. The study answered the main research question: *What understandings of science appreciation can we gain from the storied experiences of non-STEM students?*

Moreover, the following are the sub-questions that concentrate on answering the central question:

1. What significant life experiences led to the participants' appreciation of science?
2. What influenced their decision not to pursue a STEM strand despite their science appreciation?
3. How are their experiences in a non-STEM context shaping their plans?
4. What reflections about science appreciation, as an unpursued path, can we glean from the stories of the non-STEM students?

LITERATURE REVIEW

Nature of Science

Nature of science (NOS) is a critical element of scientific literacy that improves students' understanding of science concepts and makes educated judgments regarding scientifically based personal and societal problems (National Science Teaching Association, 2021). Various science education reform documents globally have recently promoted NOS as a vital learning product. In addition, the reflection that NOS has been a continuing objective of science education and is now getting enhanced importance to be understood by high school graduates who do not have good opinions of NOS (Lederman, 2007).

In 2016, NOS was reconceptualized and incorporated scientific knowledge, practices, and other family categories. This concept gives a helpful framework for arranging science curriculum and instruction and provides rise to multiplicative visual tools that assist the execution of a deeper understanding of and about science (Dagher & Erduran, 2016). A study conducted in Delphi, Greece, suggests that a critical attitude is one of the strong arguments that should make part of science education for people (González-García, Blanco-López, España-Ramos, & Franco-Mariscal, 2021).

Moreover, explicit focus on aspects of epistemology such as (a) student as sense-maker, (b) testing limitation/applicability of knowledge, (c) evaluation of conceptual understanding is essential to improve knowledge of non-STEM students in science (Johnson & Willoughby, 2017). Likewise, an analysis found that non–STEM majors are more likely than biology majors to hold misconceptions about the nature of science. Yet, they are not entirely unaware of how science works (Cotner, Thompson, & Wright, 2017).

In a study conducted in Japan, they found out that interdisciplinary studies are essential for the development of critical thinking, and the ability to translate ways of thought between different fields to cultivate graduates is necessary to leading the Japanese industry in collaboration, innovation, and entrepreneurship, policy (Yamada, 2018). Similarly, for non-science majors, creating socially-focused and interactive exercises improves the relevance of the coursework, meaning that the activity can be an efficient and effective way to be engaged in science. It also empowers students to cultivate a higher scientific literacy level with their peers' assistance (Ramirez, Pinedo, & Forster, 2021).

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Appreciation of Science

Mugaloglu (2014) mentioned that appreciation of science acknowledges the significance or merit of science and chooses the scientific reason between the clattering worldviews. An analysis noted that the nature of science's (NOS) role is vital for science appreciation. One must understand the NOS before possessing an appreciation of science. Hence, in the context of the broader goals of scientific literacy, one of its implications is to develop and integrate activities in teacher training programs to enable prospective science teachers to understand the nature of scientific theories and to distinguish an idea from a pseudo-scientific explanation (Mugaloglu & Erduran, 2012).

As per Matthews (2002), visual appreciation of nature must be directed by familiarity with it. That is, aesthetic understanding involves examining an object and reacting based upon it, which is enriched by scientific knowledge of the workings of nature. Therefore, individuals will better understand and appreciate the world and science if they live and experience it (Carlson, Koenig, & Harms, 2013).

Moreover, when one appreciates science, it brings various benefits such as (a) gaining self-help, (b) driving strong economies, (c) becoming responsible citizens by being stewards of the environment, (d) working smarter, not harder, (e) respecting future generations (Stephenson, 2020). Likewise, pushing beyond shared aims to attributes that make each person distinctive, intricate, and dynamic—seeing distinct individuals, not just an identical group—is necessary to appreciate how science is fundamentally human and vital (Wong, 2002).

Furthermore, it is well-known that the aim of school and education ought to be more than to get a good job, teach responsible people, or make children participate in a worldwide society. Most people regard education as should provide to foster beautiful experiences and assist aesthetic and creative means of viewing, acting, and being in the world. Besides, many science experts believe education should nurture the aesthetic sense of essential and convincing ideas—in this instance, science concepts. Thus, the pedagogical approaches we used seemed to facilitate these sorts of events, and appraising ideas that arose seemed linked to intentions or explanations further than the merely instrumental (Girod, Rau, & Schepige, 2003). Correspondingly, Shamos (1991) argued that a more rational purpose in educating non-scientists concerning science could be science appreciation. Like appreciation of other things, science appreciation may well be nurtured without demanding the mastery of scientific aspects that experts ought to understand. Besides, the appreciation of science by a large part of our society would have a more pragmatic result than the fulfillment of scientific literacy.

Theories Supporting Science Appreciation

Broaden-and-Built Theory of Positive Emotions. This theory explains the form of positive emotions in terms of broadened thought-action repertoires and describes their role in building and sustaining personal resources. The idea gives a new point of view on the developed adaptive importance of positive emotions (Fredrickson, 2001). This evidence indicates that positive emotions broaden the boundaries of attention, cognition, and action and build physical, intellectual, and social resources. Still, much of this proof, preluded by the broaden-and-build theory, gives only the model's implicit aid. Thus, this theory remarks that science appreciation can be evident in a person with scientific knowledge and awareness. Through this lens, positive emotions free us from being creative, playful, curious, and experimental, and from these actions flow opportunities to achieve new physical, social, and intellectual resources.

Kolb's Experiential Learning Theory. This theory is defined as a learning development where knowledge results from understanding and translating an experience. It is recommended that learning needs the acquisition of abstract ideas that can apply flexibly in a wide range of circumstances (Growth Engineering, 2021). Consequently, it can affect the science appreciation of learners even if they are not in a STEM class as long as they are packed with scientific experiences that can later be translated into scientific appreciation. For instance, as an application of science, technology plays a vital role in our lives today. Learners can show appreciation for science when they witness or experience its significance in their lives. Experiential learning lets students instantly use what they are learning for real-world experiences. This theory helps them preserve the information better. Students benefit considerably from understanding that helps them prepare for the real world. Experiential learning focuses on actual conditions to help better prepare for their future (Healey & Jenkins, 2000).

Scientific Constructivism Theory. Constructivism is a viewpoint in the philosophy of science that holds that scientific knowledge is created by the scientific community, which tries to quantify and build models of the natural world (Fosnot, 2013). Initially, it came from Piaget's theory of constructivism which contends that individuals generate knowledge and make meaning from their experiences. His theory encompassed learning theories, teaching methods, and education restructuring. Integration triggers an individual to combine new experiences with old experiences (Taylor, 2015). In the teaching and learning process context, students are the focus of teaching in learning. Without students' initiative involvement, education is pointless. Similarly, in teaching, teachers are the topic of instruction. Teachers cause to inspire and drive students to learn knowledge successfully. Therefore, teachers perform a vital role in igniting scientific appreciation among learners since they are the prime movers of the process (Qiong, 2010). Besides, several research studies show that constructivism urges learners to think and examine their understanding through active meaning-making. Thus, constructivism supports learning science in a real sense, i.e., as a body of knowledge and a process for making sense of situations. Likewise, the integrated standards of constructivism account very well for these statements. Detailing them, first, knowledge is keenly built up from within by individuals and by communities. Second, language-based social connections are fundamental to the creation of knowledge. Third, the role of cognition and language, employed to convey understanding, is functional and adaptive. Lastly, cognition and language are intended to bring coherence to

an individual's realm of experience and a community's knowledge ground, respectively (Cakir, 2008).

Dewey's Aesthetic Theory. This theory is naturalist because just an experience as intricate as aesthetic experience is seen as unceasing with the dealings that he considers embody the connection of even the simplest biological organisms to their environments. Dewey asserts not restricting aesthetics to art or artistic to aesthetic value. As much as poetry, arithmetic and science should sometimes be appreciated aesthetically. Dewey thought that art is sometimes valued for itself and can also be applied to other ends. (Leddy & Puolakka, 2021). Thus, the natural nature of an aesthetic experience, which carries underlying associations between art and science, involves the essence of the recommended solution. Furthermore, instituting a meaningful aesthetic connection creates a fruitful foundation for bridging the hard sciences and humanities gap. In Dewey's viewpoint, the disparity between arts and sciences never occurred as defined by conventional philosophy and science. Instead, the differentiation of modes of human activity arises from seen results and the meaningful application of these results in further challenges that exhibit distinctive existential characteristics. Natural sciences and humanities only diverge after such distinctions are valuable and necessary to build human culture and living principles. Names of disciplines are derived from descriptions that signify the natural rise of a diversity of human goals and the deliberate means of achieving them. Moreover, natural sciences and humanities function similarly through the experience of a human being engaged in the activity – whether it be concrete, conceptual, or a combination of both. Dewey's aesthetic theory implies that no physiological variations occur between the aesthetic of fine art and the aesthetic of science. His picture of the collective experiential foundation represents an alternative basis for developing the discussion between natural sciences and humanities. It begins with a genuine connection instead of searching for one after different areas of intellectual attempt are *a priori* separated as independent groups (Ruoppa, 2019).

Overall, the existing literature and students pointed out that science appreciation of an individual is directly linked with the nature of science (NOS). Thus, anyone can appreciate science through their experiences. It is suggested that this practice can be intensified in a teaching and learning environment with well-designed activities and opportunities, including the nature of science. These points are supported by various theories, such as positive emotions, experiential learning, constructivism, and aesthetics.

Conceptual Framework

A conceptual framework explains the research path and assists in stimulating research while ensuring the extension of knowledge by providing direction and impetus to the research inquiry (Adom, Hussein, & Adu-Agyem, 2018). The phenomenon of interest for this study is the science appreciation of non-STEM learners.

Figure 1 presents the role of significant life experiences of non-STEM students, as influenced by internal and external elements, in having science appreciation. Moreover, it also includes other factors contributing to this phenomenon, such as understanding the nature of science and the societal impact and relevance of these experiences.

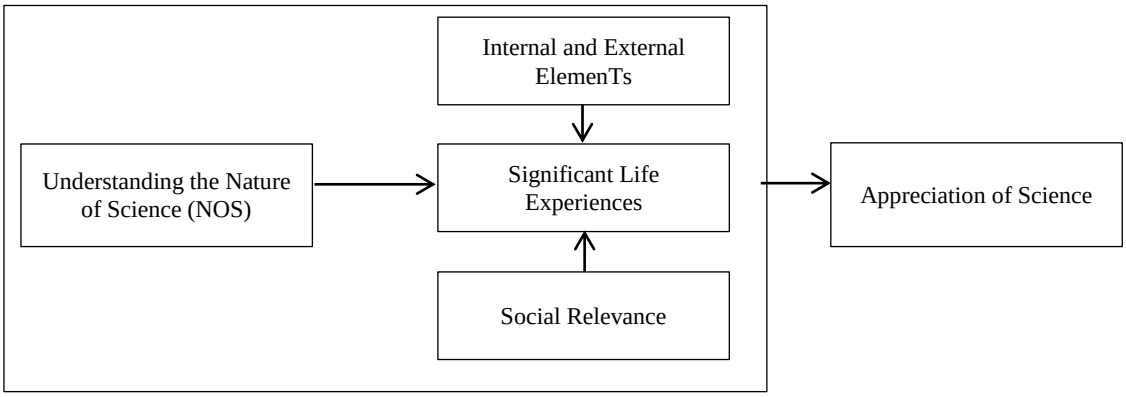

Figure 1. *Conceptual framework of the study*

MATERIALS AND METHODS

The essential attributes of qualitative research are: (a) the researcher pursues to understand how people make sense of their experiences; (b) the researcher is the main instrument of data collection; (c) the procedure is inductive, and (d) the final product is richly descriptive (Aspers & Corte, 2019)

A qualitative researcher tries to understand and make sense of phenomena from the participant's standpoint. Since this study sought to uncover and describe the meaning of science appreciation in the storied experiences of non-STEM learners, the study is interpretative and descriptive by nature. Therefore, a qualitative research design is suitable for this study.

Furthermore, this study used a narrative approach, a study of "the ways humans experience the world". It gives researchers insights into the phenomenon (Butina, 2015). The emphasis of narrative research can be on the experiences of one or more individuals. In this educational research effort, a narrative study was utilized to look at the experiences of an individual; the narrative design was most fitting for this study because it permitted the researcher to investigate the growth of science appreciation among the participants by understanding their storied experiences. Moreover, the researcher used an oral history approach to assemble personal reflections on events from one or several participants. In this case,

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the participants' storied experiences developed science appreciation even in a non-STEM context. Also, this study utilized a categorical-content model of narrative analysis to concentrate on content themes within the individual narrative.

Researcher's Role

The researcher plays a critical role in qualitative research methodology since the researcher is the primary data gatherer and a "key instrument". The qualitative researcher collects data by analyzing documents, studying behavior, and interviewing participants. They can use an instrument, but it is devised by the researcher using open-ended questions. They do not use or depend on questionnaires or tools established by other researchers (Creswell, 2013).

Since the researcher is a primary data collector, building a connection with the participant became inevitable. The researcher established a close bond with the participants for this research. With the researcher's background knowledge in education and experiences from his professional role as a science teacher in many educational institutions, the researcher could relate to the participants' stories, establish credibility with participants, and understand the context when interpreting data. The researcher told the participants about his background and introduced himself before the interview.

Cooperation between the researcher and participants was also vital in gathering and scrutinizing narrative data. The researcher actively collaborated with participants and carefully listened to their stories, looking forward to making them feel their stories are essential and they are being heard and working with the participants to lessen the gap between the stories told, and the narrative stated. During the research process, the researcher collaborated with the participants.

Even though bonding and collaborating with participants were essential in qualitative research, the researcher had to be careful regarding the authenticity of the data. Data distortion may happen when the participants do not tell the true story for more motives, such as worrying about the actual story or simply for memory errors. The researcher's target was to uncover stories to be told, but the researcher had to be vigilant about the likelihood of data distortion. To form a relationship with participants to deliver authentic and truthful answers, the researcher set up an initial five-minute interview before the actual interview to have a relaxed conversation with each participant. During the interview, the researcher clarified participants' right to refuse to answer questions during the actual interview. Also, the right to withdraw from the study and the anonymity of their identities; and told the participants about the usefulness of the research outcomes to other non-STEM students who have science appreciation to better pursue the path they intend in the future were also involved.

The Participants

The sampling technique applied in the study was based on the research problem and questions of the study. Since this study explored the science appreciation journeys of purposefully selected non-STEM students, nonprobability, purposeful, and criterion sampling were most suitable as they allowed the researcher to gain insights and learn about the phenomenon. The population being studied comprised non-STEM students in Metro Manila. The main criterion for the sampling was the participant should have shown science appreciation and be currently enrolled in a non-STEM strand or track in the Senior High School. These participants focused on how their significant life experiences led to their science appreciation and what influenced their decision not to take a STEM track despite science appreciation. Moreover, this research also explored how their experiences as non-STEM students shape their plans for the future and what reflections we can have on their stories of science appreciation as an unpursued path.

Given this description of the participants and the purposeful sampling criteria, the following section describes the researcher's procedure to implore informants for this study. The number of participants for qualitative studies is generally much smaller than that of quantitative studies since the result does not generalize. Collecting and analyzing qualitative data is a labor-intensive undertaking. Utilizing a large sample in qualitative research is time-consuming, expensive, and unfeasible. In deciding on sample sizes, several researchers provided recommendations for the sample size. The potential number of participants who qualify in the set criteria is five. The sample size is enough to give helpful information for the conduct of this study.

Data Collection

In the data collection process, a researcher should find the data types that will address research questions. The research question of this study aimed to explore the science appreciation of non-STEM students. The narrative design is the most appropriate for this study as it lets the researcher gather personal reflections on participants' science appreciation through their storied experiences. The semi-structured interview method was applied to collect narrative data. Since the interview with the non-STEM students, as the participants, may include sensitive questions, data distortion may take place when the participants are worried about telling the true story. To relieve this problem, this study utilized only a personal interview, not a focus group interview.

Initially, the researcher looked for prospective participants in the schools with which he was formerly affiliated. The researcher followed the research protocols by requesting permission to conduct interviews to safeguard the human subjects. The following target participants' criteria were included in the request: (a) the participant must be a non-STEM senior high school student, and (b) must have a medium to a high level of appreciation of science. Also, the invitation email accompanied by the informed consent form (Appendix B), which explained the participant's right to decline to participate or retract at any time during the study, was sent to the potential participants.

Second, a pilot test is an integral component of interview preparation. The pilot interview aided the researcher in identifying flaws, shortcomings, and weaknesses in the interview design. The researcher tested the interview protocol with a former colleague in the pilot process. The interview protocol followed the same method as the actual research interviews. The pilot interview helped the researcher establish the time needed for each participant, tested the interview questions, assisted the researcher in preparing for the

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interview, and validated the accuracy and clarity of the interview questions. The researcher reviewed and refined the interview questions after the pilot test.

Third, the semi-structured interview was done via Zoom video conferencing due to the current pandemic. Before the interview, the researcher-built rapport with the participants by raising personal questions. Also, the researcher explained the study overview, confirmed participants' information to be included in the study, clarified the interview process, got the consent form, and validated that the candidate did not have problems expressing their experiences through a five-minute warm-up interview. Similarly, when conducting the interview, the researcher reminded the participants about the statement about recording the interview in the consent form and asked for permission to record the interview digitally. Then, the researcher conducted the actual interview where the researcher also paid attention to the three listening levels: (1) listening to what was being said, as well as the "inner voice" of the participants, (2) filtering out unguarded responses that are irrelevant, and (3) remaining aware of the overall interview process, and being sensitive to nonverbal cues. Each interview had an estimated 30 to 45 minutes long to avoid interview fatigue. The participants decided on pseudonyms to use so that their stories would be fruitful and well-presented during the analysis as a substitute for using codes.

Moreover, the interview questions aimed to answer the main research question: *What understandings of science appreciation can we gain from the storied experiences of non-STEM students?* Similarly, the interview questions sought to elicit helpful information from the storied experiences of non-STEM students to understand their science appreciation better. Table 1 shows the alignment of the interview questions to each research sub-questions made to know how the participants gain and maintain science appreciation despite enrolling in a non-STEM track.

Table 1: Alignment of the interview questions to science appreciation experiences

Research sub-questions	Interview Questions
1. What significant life experiences led to the participants' appreciation of science?	1.1 What field of science are you passionate about, or do you like the most? 1.2 When was/were that occasion/s in your life motivated your science appreciation? 1.3 How did you know that the experience/s sparked your science appreciation? Kindly bring us to that moment of your life experience/s.
2. What influenced their decision not to pursue a STEM strand despite their science appreciation?	2.1 When did you decide not to take up a STEM strand? 2.2 What or who influenced your decision to pursue a non-STEM strand despite your science appreciation? 2.3 How could you decide not to pursue a STEM strand despite your appreciation of science? Kindly take us to that moment of this decision-making process.
3. How are their experiences in a non-STEM context shaping their plans for the future?	3.1 What significant experience/s did you have in a non-STEM environment that you still contribute to your appreciation of science? 3.2 How did that experience/s manifest science appreciation? Kindly bring us to that significant experience/s of yours in a non-STEM learning environment where your appreciation of science was still evident. 3.3 What do you intend to pursue after graduating from Senior high School? 3.4 How did your experiences in a non-STEM learning environment or situation impact your plans? Kindly tell us a particular situation of your experience in a non-STEM learning environment that you think is influential in determining your plans for the future.
4. What reflections about science appreciation, as an unpursued path, can we glean from the stories of the non-STEM students?	4.1 What thoughts regarding science appreciation did you have in not pursuing a STEM strand? 4.2 How did you preserve your appreciation of science in the face of being a non-STEM student? Kindly give us your ways of keeping your appreciation of science despite enrolling in a non-STEM strand.

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Once the interviews were done, the researcher sent a thank-you email to the participants within 24 hours after the interview. The interview was transcribed using transcription software, but the researcher double-checked the accuracy of the transcriptions. The transcription process was done three days after the actual interviews. Within one week after the interviews, the researcher emailed the transcripts to the participants to check the accuracy of the content or data auditing.

Additionally, the researcher wrote notes about his observations and interpretation of the story told during the interviews. The notes helped the researcher record the participant profile and avoid distorted information, which could have happened if the researcher had relied only on the researcher's memory. Furthermore, the researcher helped prevent the effect of the researcher's biases through reflexive journals that reflected the researcher's assumptions and biases on the research development. A reflexive journal was the researcher's reflections on "assumptions, worldview biases, theoretical orientation, and link to the study that may influence the study". Thus, writing a reflexive journal was an ongoing process to guarantee that the findings were from the experiences and the participants' worldviews, not the researcher's preferences.

Data Analysis

The analyzed data was primarily from the transcriptions of the interviews. Additional data came from the researcher's notes and reflexive journal. In examining the data, the researcher looked for themes from the content at both manifest and latent levels, themes directly observed in the narrative, and those that lay beneath the narrative.

To conduct narrative analysis, data can be analyzed through four stages of vertical and horizontal analysis (Foxall, et al., 2021).

1. Stage one: Restorying of narrative data was done. This procedure involved rewriting, reorganizing, and reiterating the stories such that critical elements were analyzed and chronologically sequenced into a coherent whole.
2. Stage two: Narrative analysis started when interpretive stories were composed of each narrative using narrative analysis through McCormack's interconnected analytical lenses. These interpretive stories considered the researchers' perspective of the participants' narratives.
3. Stage three: This stage encompassed the final stage of vertical analysis, with each narrative and the interpretative story being further examined to emphasize evolving issues. Tabulated reviews of substantial issues within each participants' narrative were generated.
4. Stage four: During this stage, themes emerged across the entire data set and were an in-depth analysis to reflect all the narratives for connections (horizontal analysis).

Figure 2 summarizes the stages of the data analysis employed in this study.

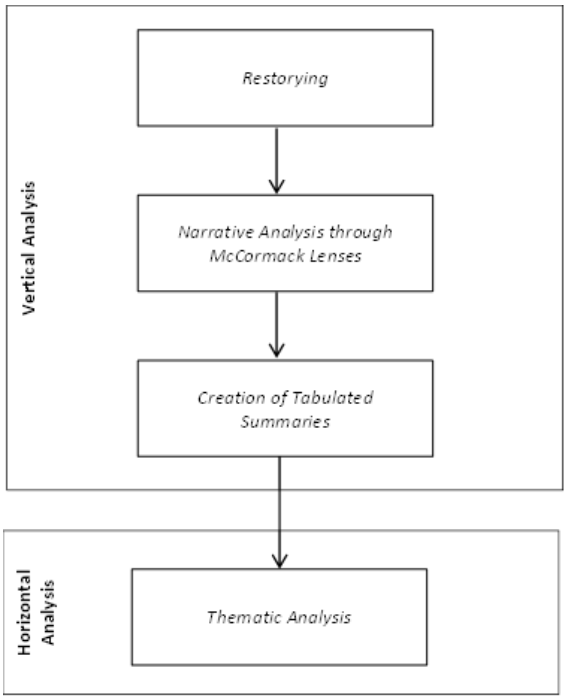

Figure 2. *Four stages of narrative data analysis*

Regarding data storage, protection, and retention, all the data were kept in digital format. The video recordings of this study's interviews were saved to the researcher's laptop computer. The researcher used transcription software to transcribe the interviews in MSWord format, which was converted to PDF format. The signed consent forms and the researcher's notes were also saved in PDF format. Once converted to digital format, all paper documents were subsequently destroyed. Likewise, all digital files, both audio-visual and PDF, were saved and kept on a password-protected (secure) USB flash drive in a locked cabinet at the researcher's home for double protection, i.e., to protect the data from physical damage and tampering, loss, and theft. Lastly, the retention period for research data varied, depending on the need for data auditing. This study was unfunded, and the data of this study have been retained and will be destroyed per the schedule in Table 2.

Table 2: Data storage, protection, and retention

Data Types	Data Format	Retention Period	Location	Final Disposition
Signed consent forms	PDF	After research approval	Password-protected (secure) USB flash drive in a locked cabinet at researcher's	Destroy

	home
Recordings of interviews	mp4
Researcher's notes	PDF
Transcriptions of interviews	PDF

Managing the Trustworthiness of the Study

There are several critics of the trustworthiness of qualitative research for its validity and reliability cannot be determined similarly to quantitative research. The idea of trustworthiness varies between quantitative and qualitative research because the researcher sees trustworthiness from a different paradigm. As a result, qualitative researchers' conceptions of reliability and validity differ from quantitative analysis. Qualitative researchers seek to understand the phenomena of interest and do not need to ascertain reliability, i.e., the result can be replicated in other cases or populations. Regarding the validity of instruments, the qualitative researcher is the instrument; thus, the validity of qualitative research implies the researcher's ability and effort to guarantee that the findings are consistent with reality. Qualitative researchers avoid using reliability and validity (Leung, 2015). Reliability and validity are not regarded independently in qualitative studies, and the researchers would instead use different terms, such as credibility, transferability, and trustworthiness.

Credibility. Many related issues have been discovered from others' research to prove the study's credibility. These are (a) use of the proper methodology, (b) extended engagement between the researcher and the participants, (c) correct selection of participants through purposeful sampling, (d) data triangulation on several sources such as interview notes, transcripts, observations, and journal, (e) gaining the authenticity of the stories told, (f) encouraging peer scrutiny, (g) consenting a member check or participants' confirmation of data narrative through transcripts, and (h) serious reflection done by the researcher (Cutcliffe & McKenna, 1999).

Dependability. To increase dependability in quantitative research, the researcher must show that if the work were replicated, in a similar context, with the same methods, and with the same participants, similar results would be obtained (Elo, et al., 2014). This study gives detailed evidence about the research design, its execution, participant selection, data gathering process, and reflective journals of the researcher. Additionally, the researcher's course professor assisted the researcher in assessing the methodologies to ensure the dependability of the methods used in this study.

Confirmability. The concept of confirmability can be coupled with objectivity in a quantitative study. A quantitative researcher uses instruments, such as tests or questionnaires, to ensure that the instruments are not reliant on human skill and perception and are free from researchers' biases. Since a researcher is a key instrument in qualitative research, confirmability varies from quantitative analysis. Though a qualitative researcher cannot prove that the findings do not depend on a researcher's skills or perception, a qualitative researcher must ensure the confirmability of the results by presenting that the findings are from the study's participants, not from the researcher's preferences. To address this issue, triangulation plays a role in ensuring the research's confirmability and credibility (Korstjens & Moser, 2018). The researcher will triangulate data sources in this study, collecting data from multiple informants and sites. This process of comprehensive methodological description that allows the reader to trace how the data ultimately leads to the finding is called an audit trail. The researcher will use the audit trail approach by gathering essential data. The six kinds of information to be collected to inform the audit process are raw data, data reduction and analysis notes, data reconstruction, synthesis products, process notes; materials related to intentions and dispositions; and preliminary development data.

Transferability. Readers may transfer with a thick narrative of the phenomenon provided in a study. However, before any transferences, supplementary information, together with the number and location of the sites, information regarding participants, data collection method, the length of data collection periods, and the point when the data is collected, should be described in the study.

RESULTS AND DISCUSSION

In this study, five non-STEM senior high school students shared significant life experiences that influenced their science appreciation. The stories told provided personal experiences as perceived by each student. A narrative of each non-STEM senior high school student's experiences unfolded the subjective meaning of their science appreciation. Each story also describes critical incidents and the development of each science appreciation.

The purpose of this chapter is to present the findings related to the central research question: *What understandings of science appreciation can we gain from the storied experiences of non-STEM students?* The themes that arose for each sub-question helped in organizing the findings. This organizing method is a systematic way to help reveal personal insights on science appreciation from each non-STEM student's experiences.

Participant Profiles

The researcher achieved data saturation after interviewing five non-STEM senior high school students who participated in this study. Each participant provided met the three criteria: (1) non-STEM student, (2) with medium to a high level of science appreciation, and (3) with good scholastic standing in science subjects and participated in a 30–45-minute interview. Participant demographic and background information follows, with a brief participant profile.

The interviews elicited more detail on their background, including their educational background, hobbies, and interest. This information is listed in Table 3.

Table 3: Demographics and backgrounds summary

Pseudonym	Gender	Age	Grade Level	Track/Strand	Hobbies/Interest
Buttercup	Female	17	12	Academic – Accountancy, Business and Management (ABM)	Reading and watching sci-fi movies and science-related documentaries
Erika	Female	18	12	Academic – Humanities and Social Sciences (HUMSS)	Watching sci-fi movies and reading books of different genres
Henry	Male	18	12	TVL-Electrical Installation and Maintenance	Participating in outdoor activities such as camping
Ysia	Female	17	12	TVL-Cookery	Participating in camping activities and reading fictional books
Aly	Female	18	12	TVL-Cookery	Playing various sports and watching Koreanovelas

Individual Story

Buttercup. She is 17 years old and is currently a graduating senior high school student taking the Academic track (Accountancy, Business, and Management). She is diligent with her studies and performs above standards in her classes, especially in science. She is a consistent honor student during her primary and secondary school years. She loves reading books and watching sci-fi movies. Other than that, she is also into watching science-themed documentaries. Concerning her science appreciation, Buttercup mentioned that her interest in science started in Grade 4. She has a science teacher who taught them the very essence of science. According to her, every time her teacher discusses a lesson, he never leaves the classroom with a single student who does not understand the lesson. Their class was very interactive. This life experience motivated her to love and appreciate science. However, when Buttercup was about to decide which track/strand to take in Senior high school, she was greatly influenced by her parents since they supported her studies. She did not have the liberty to decide for herself. On the other hand, even though she enrolled in an ABM strand to pursue an Accountancy course in college, her passion for science did not diminish. She is still into science despite her being a non-STEM student. Buttercup maintained her science appreciation by engaging in various scientific for in school. For her, if given a chance to pursue a STEM-related course someday, she will still go with it because it is her dream, after all. As of now, Buttercup realizes that having scientific values helps preserve science appreciation. As a science-minded person, she understands the importance of science to all the members of society. Also, she became more of an environmental conservationist because she believes saving the environment is everyone's responsibility.

Erika. She is 18 years old and currently a graduating senior high school student taking the Academic track (Humanities and Social Sciences strand). She loves watching sci-fi movies and reading books of different genres. She is her class debater and wants to become a lawyer someday. She also likes participating in various fundraising events to help conserve the environment. Her appreciation of science started because of her Physics teacher in Junior high school. She was amazed by how her teacher taught them science concepts, primarily when they were explained using real-life scenarios or experiences. Also, many extra-curricular activities related to science contributed to her science appreciation. However, due to the influence of her peers and family, she was unable to pursue a STEM-related strand in Senior high school due to financial reasons and the difficulty of the strand. In addition, her parents wanted her to finish a Law degree which is why she took the HUMMS strand because it is more aligned than the STEM strand. Although she is not in a STEM learning environment, she grabs every opportunity related to science because it adds to her motivation to study. Erika said that if she has a stable job and can finance herself in the future, she will still pursue a medical course which she has always wanted since she was a child. To preserve her appreciation of science, she joined various fundraising events about saving the environment. With this, she can show her being an eco-warrior because, according to Erika, our environment is being destroyed, and it is our job to do what is right.

Henry. He is 18 years old and currently a graduating senior high school student taking the Technical-Vocational-Livelihood track (Industrial Arts strand). He is the current president of the student government organization of his school in Laguna. He is an outdoorsy person, so he loves to join camping activities. He grew

up with his grandparents, and they are supporting his studies. As a TVL student, he could fix minor electrical problems they encounter at home, which indicates that he can apply the skills needed for an EIM student. Henry grew up with his grandparents, so they decided to take a TVL track in Senior high school. He loved to be with nature as a child because he was always amazed by it. This was when his science appreciation started. His love for science intensified when he became more immersed in the environment through various camping activities in school. In reality, he always wanted to pursue STEM in Senior high school, but since his grandparents support his studies, he cannot go against what they wanted him to take, which is the TVL track. With this, he just enjoyed the experience of being a TVL-Electrical Installation and Maintenance student. Even though he failed to enroll in the STEM strand, his appreciation of science is still in his heart, especially since some of his classes' lessons are related to science. Also, he can apply the skills he learned in the classroom to real life, like repairing basic electrical wirings at home. As a result, this situation woke his intention to become a Mathematics teacher in the future when he has all the means to support his studies by himself. When he became a teacher, he wanted his students to realize and appreciate science and its applications. He also wants to impart his knowledge to others and help them reach their full potential. Also, to inculcate in them to do things significant to their lives. Even though he did not pursue STEM, Henry's appreciation of science did not change. He even appreciated science more because, at some point, he thought about the applications of science that does at home, especially regarding fixing some appliances at home, which he knows involves science concepts. Also, the simple things at home are rooted in his deep science appreciation. At home, he always follows proper waste segregation because he knows that he can help save our environment by doing this.

Ysia. She is 17 years old and currently a graduating senior high school student taking the Technical-Vocational-Livelihood track (Home Economics strand). She likes to join various school clubs in her school and camping activities. Her siblings support her with her studies. She also loves reading fictional books. Ysia's science appreciation started when she was in Grade 7. She joined various camping activities, and they were told to use all available materials that they saw in nature to do simple chores like cooking. With this experience, she realized the importance of science for her. When she transferred to Manila from Bulacan, she was a bit late for enrollment, so she could not get the track she wanted, which was the STEM strand. For the sake of not stopping them from going to school, she enrolled in a non-STEM class that is available in the school near their residence. Since her family also influenced the decision not to take the STEM strand. She still wanted to pursue a STEM-related course someday if given a chance and the resources to finance her studies. She got this character from her science class that, as a person in science, we must decide logically and objectively. Furthermore, she preserves her science appreciation as a non-STEM student by reading science books and joining environmental conservation because she knows how important our efforts are in saving the environment. Also, at home, she always follows proper waste disposal so that in her way, she can help protect the environment

Aly. She is 18 years old and currently a graduating senior high school student taking the Technical-Vocational-Livelihood track (Home Economics strand). She loves playing various sports, hanging out with her friends, and watching sci-fi movies. She is very passionate about science. She loves Biology so much. She dreamed of becoming a nurse someday because she always wanted to serve people who needed her care. She has drawn her inspiration from her grandmother, who died due to sickness. She loves posting content on TikTok and watching Koreanovelas. Aly's science appreciation was influenced by her science teacher, who pushed her toward the said field by letting her realize its importance, especially during the current situation when science is in great demand. She could not take a STEM-related strand in Senior high school because of her initiative and saving their family's resources due to this pandemic. She knew that the STEM strand was financially demanding, so she chose other strands that would not cost much of their financial resources. According to Aly, she will pursue becoming a nurse if she has her own money to finance her studies. As a non-STEM student, the activities/performance tasks are centered on the current situation, which is the pandemic. She finds it interesting because she can relate more to the situation and does the tasks well. In the class, they were asked to create infographics to educate people using social media about the health and safety protocols to be followed to prevent the spread of COVID-19. With these activities, she appreciated science even more because of its need during this health crisis. Also, Aly was able to preserve science appreciation by watching science documentaries. With this pandemic, she always cleans the house because she knows it is one way to be safe from COVID-19. In addition, Aly teaches her younger siblings to manage their waste correctly because she believes they can conserve the environment, which many people are now destroying with this small step.

Key Themes

The following themes were developed from the interview transcriptions based on the four sub-questions of the central research question, "What understandings of science appreciation can we gain from the storied experiences of non-STEM students?" Four pre-defined themes provided the foundation for the analysis of participants' narratives. First, was the theme of 'significant life experiences', which revealed particular life experiences of each participant at some point in their life that sparked their science appreciation. Second, was the theme of 'influences not to pursue a STEM strand', which gave details on specific scenarios or situations, or persons greatly influenced their decision-making process not to take a STEM strand despite their science appreciation. Third, was the theme 'shaping plans in a non-STEM context', which uncovered how the participants' experiences in a non-STEM learning environment impact their plans for their future. This theme shows whether the participants will still pursue their science-related passion or go a different path. Lastly, the theme of 'reflections from the stories of non-STEM students' indicated their thoughts about not pursuing a STEM strand and how they preserved their science appreciation despite being non-STEM students. Table 4 shows the themes, example codes, and frequencies that arose in the narratives and utterances of the participants.

Table 4: Themes, codes, and frequencies

Themes	Example codes	Frequencies
Significant life experiences	Meaningful learning experience	5
	Interesting activity	3
	Application of science concepts	3
	Interactive discussion	1
Influences not to pursue STEM strand	Family's influence	6
	Financial matter	3
	Peer influence	3
	Vertical alignment	3
	Practical reason	2
	Idolizing someone	1
Shaping plans in a non-STEM context	Pursuing a dream college course	6
	Career-focused tasks	4
	Contextualizing science concepts	3
	Scientific discussions with others	3
Reflections from the stories of non-STEM students	Environmental stewardship Possessing scientific values	6 5

Theme 1 - Significant life experiences

The results confirm the ideas of Johnson & Willoughby (2017) on the nature of science having an explicit focus on aspects of epistemology such as (a) student as sense-maker, (b) testing limitation/applicability of knowledge, (c) evaluation of conceptual understanding is essential to improve knowledge of non-STEM students in science. Also, it affirms the theories supporting science appreciation, such as Kolb's experiential learning theory. Regarding this theory, Healey and Jenkins (2000), stated that experiential learning could affect the science appreciation of learners even if they are not in a STEM class as long as they are packed with scientific experiences that can later be translated into scientific appreciation. Therefore, learners can show appreciation for science when they witness or experience its significance in their lives.

Meaningful learning experiences. The science appreciation of each participant, specifically Ysia, Erika, and Buttercup, was motivated by their respective science teachers. They became passionate about science because of how their teacher taught the subject to them. Also, they mentioned that when science is connected to their daily activities and its importance is explained to them, they appreciate the subject more.

> *Starting in Grade 4, I had an excellent teacher teaching science. He was very passionate and dedicated when he taught us science concepts. He always explains a science concept up to its minute details and importance*. (Buttercup)

Interesting activity. Activities such as analogies, environmental immersions, and simulations in and out of the classroom also impact participants' science appreciation. Ysia, Erika, and Buttercup mentioned that they became more appreciative of science because they enjoyed several activities that they did regarding it. These activities help in giving and making science a sense for them.

> *Because of my seniors during the camping encouraged us to explore nature and immerse ourselves in the environment. We tried living with nature*. (Ysia)

Application of science concepts. Aly, Ysia, and Henry appreciated science more because they realized its use. They could experience its applications, making a particular task easier to finish. For them, concepts without their applications are useless. Thus, hands-on experiences are essential for understanding and appreciating science even more.

> *Because of the pandemic, I realized the efforts of the nurses in the Philippines. This scenario was why I decided to take a BS in Nursing in college. Also, I remembered my grandmother, who had a personal nurse who inspired me to become a Nurse someday*. (Aly)

Interactive discussion. Results also showed that interactions in the class (teacher to student or student to student) could bring about science appreciation because they can witness scientific results from the experiments performed.

> *Whenever he discussed this in class, he was very entertaining. He always makes sure that his students interact with him. I also liked when he allowed us to do little experiments, which helped me understand and appreciate science more*. (Buttercup)

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Theme 2 - Influences not to pursue STEM strand

The results regarding this theme validate the idea of scientific constructivism theory by Fosnot (2013), who elaborated a viewpoint in the philosophy of science that holds that scientific knowledge is created by the scientific community, which tries to quantify and build models of the natural world. His theory encompassed learning theories, teaching methods, and education restructuring. Thus, society and community, including its vital facets such as family, peers, and even the current situation, are determiners and influential to ones' decision-making process.

Family's influence. Given the current pandemic situation, the participants had difficulty deciding if they were to push through with their studies since they are not used to online learning modality. With this, their decisions were influenced by members of the family who are to support their studies. The participants, such as Ysia, Henry, and Buttercup were told to pursue a track or strand with more career opportunities. Moreover, with the limited time and availability of schools offering a STEM strand, the participants opted to follow a different path.

> *Also, my decision was influenced by my grandmother. Since I enrolled late, she advised that I take whatever track is available and is near our residence. Since she will be financing my studies, I did not argue with her decision*. (Henry)

Financial matter. Due to the limited financial resources of every family because of the pandemic situation, taking up a strand by the participants is also affected. Since the STEM strand posts more expenses than any other in the senior high school, other families would consider a less expensive strand. This was noted by Aly, Henry, and Buttercup as one of the things that influenced why they did not take a STEM strand.

> *I wanted to pursue a Medicine course in college. However, according to my parents, the course is pricy, and they might not be able to support me if I pursue it*. (Buttercup)

Peer influence. Ysia and Erika's decisions not to pursue a STEM strand were also influenced by their friends who were ahead of them and had experienced being in the said strand. Most of their friends told them that the strand is complex, which could also be the same for them if they take it with the addition of the learning modality.

> *When I was in Grade 8, I heard many friends older than me say that STEM is tough for them. That is why I hesitated to take it, knowing I could experience the same thing*. (Erika)

Vertical alignment. One of the reasons why the participants did not take a STEM strand is its alignment with the course they are to take in college, which was suggested to them by their families. Therefore, they chose a strand aligned with their higher education course to save time and for practical reasons.

> *I know that the STEM strand will open many opportunities in the future. However, since the STEM strand is not aligned with the course, I am about to take in college. Thus, I decided to take a HUMSS instead of the STEM strand*. (Erika)

Idolizing someone. Looking up to a family member is also one of the reasons why they chose the path they took, deviating from the actual strand they wanted to take. Like Buttercup, she took an ABM strand because, just like her aunts, she wanted to become a successful Certified Public Accountant (CPA) like them in the future.

> *Also, I idolize my aunts, who are CPAs now, and I would like to be like them in the future*. (Buttercup)

Theme 3 – Shaping plans in a non-STEM context

The outcomes corroborate with the ideas of Fredrickson (2001) on the broaden-and-built theory of positive emotions, which explains the form of positive emotions in terms of broadened thought-action repertoires and describes their role in building and sustaining personal resources. The idea gives a new point of view on the developed adaptive importance of positive emotions. Likewise, it also agrees with Ramirez, Pinedo, & Forster (2021) that for non-science majors, creating socially focused and interactive exercises improves the relevance of the coursework, meaning that the activity can be an efficient and effective way to be engaged in science. It also empowers students to cultivate a higher scientific literacy level with their peers' assistance (Ramirez, Pinedo, & Forster, 2021). Thus, it remarks that science appreciation can be evident in a person with scientific knowledge and awareness.

Pursuing a dream college course. The current situation dictates no choice for the participants to follow the course they have wanted for reasons like other people will finance their studies etc. However, this is not the end of their dream for them. With their high motivation to still chase their dream, some plan to take a bridging or second course aligned with their desired path. That is how they show their science appreciation. They will hold on to their dream and do whatever it takes to fulfill it.

> *One impact of being a non-STEM student on my plans is that I wanted to become a teacher because I want to become an inspiration to my students. I want them to realize and appreciate science and its applications. I want to impart my knowledge to others and help them reach their full potential. Also, to inculcate in them doing important things in their lives*. (Henry)

Career-focused tasks. The participants' science appreciation became more intense even in a non-STEM learning environment. One of the reasons for this is that the activities they have been focused on are the career they are to have. Thus, they have fun doing them.

> *Even though I did not take STEM in HUMSS, I still have science subjects and enjoy them. My*

> *science teachers tried to provide us with engaging activities focusing on our future careers. With this, I could have fun in the class while doing the activities*. (Erika)

Contextualizing science concepts. Participants mentioned that they still have science subjects even in a non-STEM learning environment. For them, it is enough to appreciate science still, primarily when these subjects are taught in a manner they can relate to and have significance in their lives.

> *Even though I am on the TVL track, I am still happy because we still have science subjects and my teachers in those subjects are excellent at teaching. They provided us with meaningful learning experiences and made us realize science's significance to our daily lives.* (Aly)

Scientific discussions with others. Also, participants mentioned that interacting with others and sharing scientific thoughts with other people help them shape their plans even if they are not in a STEM environment. If they still have an opportunity to show science appreciation, it becomes helpful for them to make a sturdy plan about the path they will take in the future.

> *Also, I like participating in online scientific fora where I gain new knowledge about science and share what I know, especially regarding the applications and importance of science in society*. (Buttercup)

Theme 4 – Reflections from the stories of non-STEM students

The findings agree with Ruoppa's (2019) argument regarding Dewey's aesthetic theory, which implies that no physiological variations occur between the aesthetic of fine art and the aesthetic of science. His picture of the collective experiential foundation represents an alternative basis for developing the discussion between natural sciences and humanities. It begins with a genuine connection instead of searching for one after different areas of intellectual attempt are a priori separated as independent groups. As long as the love and appreciation of the beauty and importance of science are innate to an individual, it will remain even if his path does not align with science. On the same note, if a person can show this appreciation by being a steward of the environment and possessing scientific values, the love for science remains wherever he goes.

Environmental stewardship. The participants are aware of the connection between science and the environment. According to them, even if they are non-STEM students, they can still show science appreciation through their actions that promote care and conservation of the environment. They also radiate these actions to others because, for them, the best solution to save the environment is through collective efforts.

> *In addition, I know that climate change is getting worse. In my way, I try to help save the environment by joining fund-raising events about protecting the environment because I know that we, humans, are the main reasons why our environment is being destroyed. It is about time to give back and take care of our environment.* (Erika)

Possessing scientific values. One way of preserving science appreciation is by having scientific values. Every person in science must have these values so that the love and appreciation of someone in science will never fade.

> *We must not include our feelings and opinions in experiments by being objective. Also, I still regret that I did not take the STEM strand because I know it will open many opportunities for me in the future, and I was thinking that taking it could enrich my knowledge of science more*. (Erika)

The findings show that the significant life experiences of the participants that influenced their science appreciation happened in the school and the community, including at home. Moreover, the primary reason they chose to enroll in a non-STEM strand was due to the influence of their family and financial constraints. Although they were currently enrolled as non-STEM learners, most participants still thought of pursuing the dream college course aligned with science. Furthermore, in a non-STEM context, they can still exercise or show their appreciation of science by being responsible stewards of the environment through their scientific values.

CONCLUSIONS AND RECOMMENDATIONS

On the bases of the foregoing findings, the following conclusions are drawn:

1. Intra-curricular and extra-curricular experiences through practical science applications led to the participants' science appreciation.
2. Family, peers, and resources are the main factors influencing the participants' decision not to pursue a STEM strand.
3. Scientific discussions, motivation to pursue a dream college course, and science-related tasks in a non-STEM environment contribute to participants' shaping plans for the future.
4. Participants still possess science appreciation even though they did not pursue a STEM strand because they have scientific values that they can apply to conserve the environment.

Still based on the findings of the study and the foregoing conclusions, the researcher humbly recommends the following to the concerned individuals, groups, and Department of Education-affiliated institutions:

1. Provision of learning opportunities where students can still exercise their interests in science.
2. Through career exploration programs, assist learners on which path to take, either science or non-science-related.
3. Intensifying career guidance program with parental involvement ensures learners have the liberty to decide their future.

4. Future researchers are encouraged to make parallel studies focusing on the limitations of this study.

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