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Students' Perception and Academic Achievement in Senior High School Earth Science

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Abstract

The Philippine K-to-12 curriculum mandates the inclusion of Earth science components in the Science subject area. In senior high school, Earth science is currently a standalone subject for students under the Science, Technology, Engineering, and Mathematics (STEM) strand. In light of the present-day calls for a more sustainable future, Earth science education assumes a vital position in developing the scientific literacy and critical thinking skills of learners, especially on issues concerning the environment and natural resource management. However, research in this discipline remains scarce. Following a concurrent mixed-method research design, this study aims to look into Filipino senior high school students' perceptions about Earth science, their level of achievement in the subject, and the possible correlation between these variables. Thirty-one Grade 11 STEM students from a private school in the Philippines served as participants. Data collection was accomplished through the use of an adapted perception survey, an adopted geoscience concept inventory serving as posttest, and a researcher-made online questionnaire which elicited additional insights into students' views about Earth science. Results indicate favorable perception among students, particularly on how Earth science informs decision-making and enhances understanding of human-environment interactions. Students' achievement was found to be at an 'average' level. With regard to the association between students' perception and academic achievement, no significant relationship was established. Based on these findings, implications for Earth science education researchers were drawn and recommendations for teachers, parents, and school administrators were provided.

Keywords: *academic achievement, Earth science, Filipino, perception, senior high school*

INTRODUCTION

Earth is the only planet that humanity can consider its home in the foreseeable future (Earl, 2019). All living species depend on the planet and its resources for sustenance and survival. Unfortunately, this 'common home' (Francis, 2015, par. 1) is currently strained by a number of environmental concerns, such as global warming, water security threats, and extreme weather events (Intergovernmental Panel on Climate Change, 2014; United Nations Children's Fund, 2017). Addressing these issues requires a solid understanding of how the planet's subsystems interact with each other. As such, there is a need to promote geoscientific literacy through the development and implementation of an effective Earth science curriculum beginning at the basic education level.

As a scientific discipline, Earth science integrates concepts from biology, chemistry, and physics, as it looks into the planet's history, structure, processes, and composition (Dal, 2009; Geological Society of America [GSA], 2021; United States Geological Survey [USGS], n.d.). Through Earth science education,

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students deepen their understanding of the interactions between humans and their environment (GSA, 2021; Lewis & Lu, 2017). Knowledge of key geoscientific concepts helps in the development of a well-informed and future-ready citizenry who can capably deal with issues such as resource management, land use planning, sustainability, and energy conservation (American Geological Institute [AGI], n.d.; Lewis & Lu, 2017; Vasconcelos & Orion, 2021).

Despite its educational value, Earth science has been stereotyped to be less rigorous than biology, chemistry, and physics, and has received less attention compared to these subject areas (Huntoon & Baltensperger, 2012; Lewis & Baker, 2010; Thomas, Ivey, & Puckette, 2013). For instance, geology has been marginalized as a pre-college course in many English-speaking countries (Dodick & Orion, 2003a). Differences in Earth science instruction are likewise seen in European and Asian countries (Amijaya, 2016; Bonhoure & Rajchenbach; 2016; Bonito et al., 2016; Calonge et al., 2016; Felzmann & Hlawatsch, 2016; Kawamura et al., 2016; Shin et al., 2016). Other persistent challenges in geoscience education include the lack of qualified teachers and the underrepresentation of the Earth sciences in national standards (Orion, 2016, 2019; Thomas, Ivey, & Puckette, 2013). In two recent reports (King, 2013; King et al., 2021), it was found out that secondary-level Earth science is mostly taught by generalists and non-specialists.

To address the variability in Earth science curricula worldwide, the International Geoscience Education Organisation (IGEO) and the International Union of Geological Sciences Commission on Geoscience Education (IUGS–COGE) drafted the International Geoscience School Syllabus in 2014 (King, 2014, 2015a, 2015b). With inputs from nine countries––Australia, England, Japan, New Zealand, Norway, Portugal, Scotland, South Africa, and the U.S.––and other resources such as the International Earth Science Olympiad syllabus, the International Geoscience Syllabus was approved by senior members of the IUGS–COGE and IGEO. However, a recent survey among 51 countries shows that only 38 have Earth science components in their respective Science curriculum (King et al., 2021).

In the Philippines, Earth science competencies are part of the K-to-12 Science curriculum (Department of Education [DepEd], 2016b). In senior high school, Earth science is offered as a standalone subject for the Science, Technology, Engineering, and Mathematics (STEM) strand, while Earth and Life Science is a core curriculum subject that is required for all non-STEM students (DepEd, n.d.; DepEd, 2016c). Undergraduate programs in geology, geological engineering, environmental science, and meteorology are also offered in some universities.

Investigating students' perceptions of Earth science is an area in geoscience education research that can help address the negative stereotypes toward the discipline (Lewis & Baker, 2010). In a more general sense, students' perception of Earth science may be viewed through the lens of various theoretical frameworks, such as the social cognitive theory (Bandura, 1991) and expectancy-value theory (Eccles & Wigfield, 2002), suggesting the connection of self-efficacy, interests, and attitudes to engagement and academic success. Understanding how learners perceive the educational value of Earth science, as well as the challenges and opportunities in this academic domain, can lead to pedagogical approaches that are relevant, developmentally appropriate, and student-centered. This is consistent with the goal of education to help students acquire expert-level perceptions of their courses, which could lead to improvement in their conceptual understanding of the subject matter (Jolley et al., 2012).

The relationship between students' perception of their courses and their scholastic performance in these subjects has been the focus of investigation in both STEM and non-STEM fields. For instance, self-regulated learning and motivation, which is influenced by emotions, have been linked to students' academic achievement (Mega et al., 2014). In physics, students' beliefs have also been correlated with conceptual learning gains (Perkins et al., 2005). Similar findings among undergraduate and graduate students in Australia indicate that positive perceptions of their accounting courses led to better academic standing (Ferreira & Santoso, 2008). Meanwhile, high-performing students have shown more favorable disposition towards their teachers, self-perception, laboratory learning environment, and education in general (Ahmed et al., 2018; Luketic & Dolan, 2013; Mayya & Roff, 2004).

The present study contributes to the current body of geoscience education research in the Philippines and in Southeast Asia by examining how senior high school students' perception of Earth science relate to their conceptual achievement in the subject. Insights gleaned from the students' responses and test results offer foundational contexts for similar studies in the post-pandemic era. Furthermore, it brings back to the forefront of academic conversation the bidirectional influence of the affective and cognitive domains, especially in the context of geoscience education.

Research Questions

While local studies in science education (e.g., Guido, 2013; Montebon & Orleans, 2021; Pardo, 2017) have looked into student's perception, academic achievement, and other related topics such as attitude and motivation, a more focused investigation into the relationship between learners' perception and academic achievement in school-level Earth science remains lacking. A recent survey of published journal articles on Earth science education in the Philippines revealed that the majority delved into students' learning and conceptual changes, but studies relating students' perception and achievement were not identified (Landicho, 2025). Implications of such a study may aid in the development of pedagogical approaches and other relevant insights that can promote positive perceptions of Earth science and lead to learning progress among students. As such, this paper specifically aims to address the following research questions:

1. How do students perceive Earth science as an academic subject?
2. What is the achievement level of students in Earth Science?
3. Is there a relationship between students' perceptions of Earth science and their achievement in the subject?

METHODOLOGY

Research Design

This study followed a quantitatively driven concurrent mixed-method research design where analysis is primarily anchored in quantitative findings and supported by qualitative data (Johnson & Christensen, 2014). Key research outcomes are drawn primarily from the results of the students' perception survey and scores in a geoscience concept inventory. Additional insights into students' views about Earth science were gathered through their responses to a follow-up online questionnaire.

Research Locale

The study was conducted during the school year 2022–2023 in a private, K-to-12 college preparatory school in Laguna province, Philippines. The institution implements the standard basic education curriculum prescribed by the Department of Education. At the time of this study, the school implemented the hyflex learning modality, which replaced the full online setup during the height of the COVID-19 pandemic. Grade 11 Earth science classes were held in two separate 50-minute periods and one 100-minute session per week.

Research Participants

Thirty-one Grade 11 students from two STEM sections participated in this study. Both Earth science classes were taught by the author as the subject teacher. The majority of the participants attended the same school for their junior high school and have taken their science subject in a spiraling progression (DepEd, 2016b).

Research Instruments

Adapted Students Perceptions about Earth Science Survey (SPESS)

To address the first research question regarding students' perception of Earth science as an academic subject, an adapted version of the Student Perceptions about Earth Science Survey or SPESS (Jolley et al., 2012) was utilized. This survey examines students' perception as an attitudinal construct, identifying their position in the novice-expert continuum with regard to their beliefs about the nature and significance of Earth science (Jolley et al., 2012).

A total of 29 items that can be grouped into seven categories––memorization, science and society, mathematical problem solving, personal interest, skeptical reasoning, conceptual problem solving, and human-science interaction––were included in the adapted survey. Students rated each item using a 5-point Likert scale, with 1 corresponding to strongly disagree and 5 to strongly agree. During analysis, both 'agree' and 'strongly agree' responses were collapsed to 'agree', while 'disagree' and 'strongly disagree' were interpreted as 'disagree,' considering the differences in personal interpretation of agreement and disagreement to a survey statement (Jolley et al., 2012).

Adopting the scoring method of Jolley et al. (2012), students' scores for the SPESS were calculated using the *percentage favorable score* or the extent to which the students' responses agree with those of the geoscience experts. In this study, local Earth science professionals invited to provide their expert responses were Filipinos who have earned advanced academic degrees––Master's or, preferably PhD or its equivalent––and are actively practicing in the academe or in the industries. Hence, a percentage favorable score of 75% for a statement in the SPESS signifies that 75% of the students gave a similar response to that of the Earth science experts. Table 1 presents a sample computation of the percentage favorable score for a SPESS category composed of three survey items or statements.

Table 1. Sample Computation of Percentage Favorable Score per SPESS Category

	Statement 1	**Statement 2**	**Statement 3**
Experts' response	Agree	Agree	Agree
Student 1	Agree	Agree	Agree
Student 2	Agree	Disagree	Agree
Student 3	Agree	Agree	Neutral
Student 4	Agree	Agree	Neutral
Interpretation per statement	75% Favorable	75% Favorable	50% Favorable
Overall interpretation for the category		75% Favorable	

Geoscience Concept Inventory (GCI) Subtest

A 20-item subtest from the Geoscience Concept Inventory or GCI (Libarkin & Anderson, 2005, 2006, 2007) was used as a posttest to measure students' academic achievement in Earth science. As a concept inventory, the GCI has been used in earlier studies (e.g., Libarkin & Anderson, 2005; McConnell et al., 2006), particularly in entry-level geoscience courses and in developing assessments for both grade school and high school levels (Libarkin & Anderson, 2007). Items in the original GCI were validated by experts and developed using item analysis theory and Rasch models (Libarkin & Anderson, 2005, 2006).

All items in the GCI subtest were ensured to be aligned with the Grade 11 Earth science and junior high school Science content standards (DepEd, 2013, 2016b). The number of test items per topic was equivalent to the allotted encounter time during the term.

Individual performance in the GCI subtest was determined based on students' raw test scores. Every correct item was given a maximum of one point. If a question has more than one correct answer, the point is divided among all the correct responses.

Online Follow-up Questionnaire

After students have taken the GCI subtest and answered the adapted SPESS, a researcher-made online questionnaire was administered through Google Form. Responses to this questionnaire provided additional insights into students' perceptions of what Earth science is all about and its significance in daily life. Moreover, students identified the skills and knowledge that they consider necessary to be successful in an Earth science course.

Data Gathering Procedures

Following their initial preparation, the research instruments were subjected to validation and pilot testing. The invited instrument validators included a retired professor with two doctorate degrees in geology and education, a high school Science department chairperson with a master's degree in curriculum and teaching, and a former Earth science teacher with a bachelor's degree in education. Grade 12 STEM students enrolled in the same school participated in the pilot testing. Meanwhile, invitation letters to answer the SPESS were sent via email to the identified Earth science experts.

Data gathering was conducted towards the end of the first trimester of the school year 2022–2023. A one-hour session was allotted to administer the adapted SPESS and the GCI subtest. Thereafter, the online questionnaire was shared via email. Prior to data collection, students were oriented about the objectives of the study and were asked to submit their signed informed consent forms. Those who were aged 17 and below at the time of the study were required to secure the consent of their parents or legal guardians.

Data Analysis

Quantitative data were analyzed using the percent favorable scores and raw scores in the adapted SPESS and the GCI subtest, respectively. The percent favorable score in the SPESS corresponds to the extent to which the students' responses agree with those of the invited Earth science experts. In the succeeding section, percent favorable scores are reported alongside their respective standard errors. Meanwhile, scores in the GCI subtest are presented in terms of their means and standard deviations. The relationship between students' perception and academic achievement in Earth science was determined through Pearson correlation analysis.

Responses to the follow-up questionnaire were collated, coded, and analyzed following a deductive approach (Linneberg & Korsgaard, 2019) where the seven categories of the SPESS served as the predefined codes. Recurring themes in the students' responses were identified and used to further explain the quantitative results of the SPESS.

Ethical Considerations

This study was approved by the University Research Ethics Office of the Ateneo de Manila University (Protocol ID: AdMUREC_22_005 and AdMUREC_22_005PA). Strict adherence to the approved research protocol was observed to ensure that no rights, including anonymity and confidentiality, were infringed. When their responses are quoted, students are addressed using pseudonyms––R1, R2, R3, and so on. Participation in the study was voluntary and confirmed only upon the submission of a signed informed consent form. For participants who were below 18 years old at the time of the study, informed consent was provided by their parents or legal guardians. All research participants were free to disengage at any point during the study without consequences or penalties.

RESULTS AND DISCUSSION

This study was conducted at the end of the first trimester of the school year 2022–2023. The 31 Grade 11 Earth science students who participated in the study came from a private, K-to-12 college preparatory school in Laguna Province, Philippines. Eighteen of them responded to the follow-up online questionnaire.

Research Question 1: How do students perceive Earth science as an academic subject?

Students' perception of Earth science was determined through an adapted version of the SPESS (Jolley et al., 2012). Percentage favorable score was used to gauge the extent of similarity between students' responses to the survey items and those of the Earth science experts. In this study, 14 Filipino Earth science experts agreed to answer the SPESS. They were affiliated with local and international academic, research, and government institutions, and have completed graduate degrees in different subfields of geosciences.

The overall percentage favorable score attained by the Grade 11 STEM students shows a 71.8% (SE = 3.4) agreement with the responses of the Earth science experts. The percentage favorable scores per category range from 44.1% (Science and Society) to 98.9% (Human-Science Interaction). This suggests that the majority of students had expert-like perceptions in all but one of the SPESS categories––Science and Society. Table 2 summarizes the overall percentage favorable scores of the Grade 11 students in the adapted version of the SPESS.

Table 2. *Percentage Favorable Scores of the Grade 11 Students in the Adapted SPESS (n=31)*

Category	Percentage Favorable	Standard Error
Memorization	75.8	4.0
Science and society	44.1	5.8
Mathematical problem solving	51.6	4.3
Personal interest	85.2	1.6
Skeptical reasoning	77.4	2.5
Conceptual understanding	69.9	5.9
Human-science interaction	98.9	0.3
Overall	71.8	3.4

Note. SPESS adapted from Jolley et al. (2012)

Memorization

The Grade 11 students recognized Earth science as a discipline that goes beyond rote memorization. Based on their survey responses, they consider the ability to connect prior knowledge to what is being learned about the planet as more important than simply memorizing terms and their definitions. Nevertheless, they still acknowledge the value of being able to recall information in order to understand Earth science concepts. This observation is consistent with the notion that while surface-level memorization is never the goal of the learning process, effective memorization strategies are still essential in ensuring students' success (Klemm, 2007).

Science and Society

The *science and society* category recorded the lowest percentage favorable score among the seven SPESS categories. Jolley et al. (2012) noted similar findings and inferred that this might be due to deeply rooted societal norms. Students exhibited less expert-like views when asked about the veracity of Earth science information presented in news and government approval of scientific information. The Earth science experts disagreed with the statement that when a purported Earth science information is presented in the news, it must be true. Less than half of the students (41.9%) shared the same sentiment. Meanwhile, only

12.9% of the students held the same opinion as the experts who disagreed with the claim that government assent is needed to disseminate new Earth science ideas. These findings highlight the need to strengthen students' ability to critically evaluate diverse sources, confront misinformation, and address the decline of scientific journalism (Scheufele, 2013; Scheufele & Krause, 2019). However, understanding the intersection of science and society, media, and the government would need further experience that may go beyond the classroom. Even so, learners, especially those in STEM, are encouraged to be involved in areas such as politics and governance (Shearer et al., 2020) in view of the crucial role of science in informing society and its policymakers.

In contrast, the majority of students share the same view as the experts with regard to the importance of accurate Earth science information when making decisions that can impact society. Many of today's social and environmental concerns require solutions that are grounded in geoscientific knowledge. From the follow-up questionnaire, one of the participants emphasized "[...] how important it is to study Earth Science as these serious issues should be faced with the most amount of caution and care, especially since it could spell the fate of all and the generations to come." Student R3 added that leaders, especially those in the government sector, who are knowledgeable about Earth science are better equipped in making informed decisions.

Mathematical Problem Solving

Percentage favorable score in the *mathematical problem solving* category revealed that more than half of the students displayed expert-like perception of how equations and statistics aid in understanding Earth science ideas. More specifically, they agreed that mathematical expressions can be used to denote Earth science concepts and that there are different approaches to problem solving in an Earth science exam. However, students also expressed that they could get easily confused when Earth science lessons involve some mathematical component. This could be linked to the students' perceived difficulties and insecurities in mathematical and statistical skills. It can be noted that the Philippines was ranked second to the last in mathematics and science among the countries that participated in the 2018 PISA (Schleicher, 2019). These observations reinforce the demand for improved mathematics instruction and effective integration in other academic domains, such as Earth science.

Personal Interest

Results in the personal interest category show that students have generally positive outlook towards Earth science, particularly on how they view the subject's usefulness and their perceived enjoyment in taking the subject. Similarly, earlier studies have also correlated students' interest with enhanced learning achievement (Harackiewicz et al., 2016) and science self-efficacy (Alhadabi, 2021). Responses to the online questionnaire illustrate how personal interest influences the Grade 11 students' disposition towards Earth science. Student R4 highlighted the importance of being able to recognize the interconnectedness of the Earth's processes, biodiversity, and history. Meanwhile, Student R15 expressed a positive shift in interest after learning more about the world around him.

Skeptical Reasoning

The *skeptical reasoning* category looks into the students' way of verifying information about the Earth sciences. In this study, the majority of the Grade 11 students held expert-like views when it comes to verifying the accuracy and reliability of Earth science information. They tend to validate informational resources and countercheck Earth science ideas that are deemed controversial. As issues concerning fake news and other forms of deception emerge, this brings to the fore the significance of upholding research integrity and ethical standards (Hopf et al., 2019). Percentage favorable scores in specific SPESS statements likewise suggest that students consider discussing with peers and relating lessons to personal experiences as strategies to better understand Earth science concepts. Participants likewise identified research, comprehension, and critical thinking as necessary skills to succeed in this discipline. This view is reflected in Student R5's acknowledgement of the importance of seeking clarification when concepts seem vague and how curiosity led him to read and research more.

Interestingly, one of the statements in the conceptual understanding category received a comparatively low percentage favorable score of 32.3%. This recorded score for the statement "When I look at a landscape, I have an idea of how long it took to form." aligns with the finding of Dove (1998) regarding learners' difficulty in visualizing changes in landforms because such processes are abstract and occur over long periods of time. Indeed, the concept of Deep Time, or the planet's 4.6-billion-year geologic history, is often misconstrued because of the immensity of the time period (Clary et al., 2009) and its contrast to commonly observed short-lived events.

Human-Science Interaction

Compared to all other SPESS categories, the human-science interaction category received the highest percentage favorable score which indicates students' expert-like views on how humans affect the environment and how knowledge of Earth science informs important life decisions (Jolley et al., 2012). Responses to the follow-up questionnaire also express Earth science's role in decision-making and in addressing pressing societal concerns, such as disaster risk reduction, climate change, and pollution. Students cited the effects of human activities on the planet, and how the planet influences human interactions. Moreover, they underscored the significance of studying Earth science to effectively take care of the environment.

In summary, the category from the adapted SPESS that garnered the highest percentage favorable score (98.9%) was human-science interaction. This was followed, in order of decreasing percentage favorable scores, by personal interest, skeptical reasoning, memorization, conceptual understanding, mathematical problem solving, and science and society. The overall results of the perception survey indicate that students have a generally positive perception of Earth science. Responses from the follow-up questionnaire also denote that Earth science is useful, significant, and interesting.

Research Question No. 2: What is the achievement level of students in Earth Science?

The results of the 20-item GCI subtest indicate that the majority of the students (54.8%) achieved average scores ranging from 8 to 12. Eight students (25.8%) scored above average, while six students (19.4%) performed below average. The overall mean is at 10.4 (SD = 2.4). The given categorization of 'Above Average,' 'Average,' and 'Below Average' were based on the descriptors used by Libarkin and Anderson (2005) for the results of a 20-item GCI subtest administered to undergraduate students from 22 states in the U.S. However, when the current grading scales employed by the Philippine Department of Education (2015, 2016a) is adapted, only 11 students (35.5%) attained scores that are equivalent to satisfactory (12.9%) and fairly satisfactory (22.6%) ratings.

Table 3. *Scores of Grade 11 STEM Students in the GCI Subtest (n=31)*

Scores	Frequency	Percentage	Descriptor
13–20	8	25.8%	Above average
8–12	17	54.8%	Average
0–11	6	19.4%	Below average
Total	31	100%	

Note. The 20-item GCI subtest was adapted from Libarkin & Anderson (2005, 2006, 2007).

Several factors may have contributed to the observed performance of the Grade 11 students in the GCI subtest. This includes the learning gaps and adjustments associated with the lockdowns and restrictions during the COVID-19 pandemics. Schools were forced to suspend onsite operations and shifted to purely online or distance learning modalities. For at least two school years, students in the research locale took their examinations and other alternative assessments online and did not experience any traditional pen-and-paper tests at the height of the coronavirus global emergency. As the participants have just returned to attending face-to-face classes at the time of study, adjustments in their test-taking skills and test disposition may have also contributed to their performance in the GCI subtest. Moreover, given that learning preference bias and other forms of biases are usually associated with standardized tests (Gunzelmann, 2005), individual performance or achievement level may not be completely captured by simply looking at test scores.

A closer look into how the Grade 11 students answered each item in the GCI subtest may provide additional insights on their mastery of certain Earth science topics. Based on their computed difficulty indices (DI), items were characterized as either very difficult (DI = 0 to .20), difficult (DI = .21 to .60), moderately difficult (DI = .61 to .90), or easy (DI = .91 to 1.0), as adapted from Tobin (n.d.). Item analysis suggests that four items in the GCI were rated 'very difficult.' In addition, there were eight 'difficult' and seven 'moderately difficult' questions. Only one item was tagged as 'easy.'

Two of the very difficult questions focused on the characteristics and composition of rocks and minerals. These topics were discussed in the first unit of the Grade 11 Earth science course. Both synchronous and asynchronous activities were conducted to deliver these lessons. These include lectures, classroom discussions, worksheets, and virtual laboratory exercises. While onsite students had a chance to observe some hand specimens of rocks and minerals, this was confined to brief visual inspection due to time constraints and limited resources. Students who were attending their classes online relied only on images, videos, and other web-based resources detailing the characteristics of rocks and minerals.

The two other very difficult items in the GCI subtest zeroed in on the definition of a tectonic plate and the techniques used by scientists to calculate the age of the planet, respectively. More than half of the Grade 11 students manifested alternative conceptions (Libarkin & Anderson, 2005; Wandersee et al., 2003) such as the Earth's surface not being a part of tectonic plates (58.1%, n=18) and that analyses of fossils, rock layers, and/or carbon dating can be employed to accurately determine the age of the planet (87.1%, n=27). Petcovic and Ruhf (2008) reported similar results among undergraduate students in a Midwestern university in the US and inferred that this may be due to the persistence of previously held alternative conceptions.

Questions categorized as 'difficult' in the GCI subtest correspond to major content areas in Earth science, such as the origin and structure of the Earth, exogenic and endogenic Earth processes, and the geologic history of the planet. Students also held alternative conceptions about the presence of volcanoes along passive margins surrounding the Atlantic and Pacific Oceans. The observed difficulty level of these items can be attributed to the length of time between instruction and test administration, the need for further enrichment or reinforcement of lessons, and entrenched alternative conceptions. As an example, one item which asked about the effect of volcanic eruptions on air temperature near the Earth's surface may have been answered correctly by only nine students (29.0%) because the corresponding lesson was taught early in the trimester and a more thorough discussion of the concept was planned for the course Disaster Readiness and Risk Reduction in the next trimester.

The seven moderately difficult items and the sole 'easy' question examined students' understanding of the planet's geologic history, internal structure, and cloud formation. In particular, these questions delved into the appearance of the Earth's surface during its formation, the breakup of the supercontinent believed to have existed millions of years ago, and the physical characteristics of the Earth's internal layers. Aside from their senior high school Earth science course, earlier and repeated exposure to related topics in their spirally progressing junior high school science curriculum (DepEd, 2016b) may have contributed to the relatively high percentage of students who answered the easy and moderately difficult questions correctly.

Other factors that may have influenced students' achievement in Earth science include the length of contact time, the availability of hands-on activities, and the differences in online and onsite learning experiences in a hyflex setup. As one of the students explained in the online questionnaire, his self-rating in the subject would have been higher if he had more time to learn its contents. Furthermore, several learning competencies in senior high school Earth Science were assumed to have already been introduced in junior high school. The online learning environment and the absence of more direct teacher's supervision during the preceding two online school years could have possibly affected the acquisition of these fundamental Earth science concepts.

Research Question 3: Is there a relationship between students' perceptions of Earth science and their achievement in the subject?

The relationship between students' perceptions of Earth science and their academic achievement in the subject was determined by the Pearson correlation coefficient at 0.05 significance level. The calculation yielded a weak positive relationship, as suggested by the correlation coefficient of 0.28. To determine whether this correlation is significant, the calculated t-statistic was compared with the t-critical value. Since the t-statistic (1.59) was less than the t-critical value (2.045), the null hypothesis was not rejected. There was no significant relationship between students' perception and academic achievement in Earth science after taking the course.

To further explain the observed relationship between students' perception and achievement in Earth science, it may be helpful to draw possible explanations from the results of the first two research questions. This is also based on the understanding that correlation analysis measures and describes the extent by which two variables change with respect to each other (Gravetter & Wallnau, 2011). In this study, the majority of the participants expressed expert-like views regarding their appreciation of Earth science. Students' responses acknowledge the significance of Earth science knowledge in making informed decisions, the impact of humans on the environment, and the enjoyment of studying Earth science as an academic endeavor. Given that the participants were all STEM students, these observations were anticipated. Earlier studies have also pointed out the influence of students' likes and interest on their choice of their senior high school strand (Braza & Guillo, 2015; Malaguial et al., 2023; Mayuga, 2019). Results of the GCI subtest, however, suggest that more than half of these students were at the average (54.8%) and below average (19.4%) levels. Only 25.8% scored above average in this conceptual test. Factors that could have contributed to these test results include the students' adjustment from the previous online school years, the hyflex modality at the time of the study, limited instructional time for specific contents, as well as other variables related to the students' self-efficacy, behavior, study habits, and learning environment.

Previous studies indicate the correlation of students' perceptions and academic performance (e.g., Salifu & Bakari, 2022; Sukor et al., 2012; Villa et al., 2017). In contrast, the findings of this study indicate no significant relationship between the two variables. It can be gleaned that other factors may have influenced students' performance in the subject. Positive perceptions of Earth science alone do not automatically translate into higher conceptual mastery, especially when other contextual factors are considered. For instance, qualitative responses associated with self-efficacy were noted, signifying students' beliefs that they still need to improve in the subject and exert more effort to improve their understanding of Earth science concepts. This academic self-concept was captured in the statement of Student R2 describing his Earth science skills as "good, but not good enough." Literature also shows the association of self-efficacy with student achievement (Bati et al., 2019; Mao et al., 2021), signifying the influence of this affective variable on academic outcomes. However, students' attitude towards science is a complex construct and has been operationalized differently by previous authors (Mao et al., 2021). A more nuanced analysis of other affective factors, including those beyond the scope of the SPESS, could further enrich the ongoing discussion on the relationship between students' perception and achievement in Earth science.

Table 4. *Relationship between students' perceptions of Earth science and their academic achievement in the subject*

Variables	Correlation coefficient	Remarks	t-computed	t-critical value	Decision
Students' perceptions of Earth science x Academic achievement in Earth science	0.28	Weak positive relationship	1.59	2.045	Fail to reject null hypothesis

Students were also asked about the skills they consider necessary to be successful in studying Earth science. Research, visualization of geologic processes, reading comprehension, and application of lessons to real-life contexts were among the commonly cited competencies. On a more practical note, Student R8 acknowledged the significance of test-taking strategies and the ability to remain calm during examinations.

Some students also recognized the need for additional guidance and time allotment to learn specific Earth science concepts such as plate tectonics and geologic time. This highlights the need for quality instruction, availability of more hands-on activities, and targeted interventions to address learning difficulties. Nonetheless, students' responses suggest that they have gained confidence and better comprehension of Earth science concepts upon finishing the course. They have attributed this progress to different factors such as heightened interest in the subject, openness to learn new ideas, as well as their comprehension and analytical skills. Future researchers who may take a closer look into the matter and build upon the initial findings of this study.

CONCLUSIONS AND PEDAGOGICAL IMPLICATIONS

This study aimed to determine the perceptions of Grade 11 STEM students about Earth science and their level of achievement in the subject. It also examined any possible relationship between perception and academic achievement in Earth science. Results indicate that students have a generally positive perception of Earth science. The overall percentage favorable determined from the adapted SPESS was 71.8%.

Based on the results of the GCI subtest, the majority of Grade 11 students (54.8%) garnered average scores ranging from 8 to 12. Eight students (25.8%) scored above average while six students (19.4%) scored below average. The overall mean is at 10.4 (SD = 2.4).

Pearson correlation coefficient was calculated to determine the possible relationship that exists between students' perceptions of Earth science and their academic achievement in the subject. The computed coefficient (0.28) indicated a weak positive correlation between these variables. Further analysis indicates that students' perceptions of Earth science and their level of achievement in the subject are not significantly related, as the calculated t-statistic (1.59) was less than the t-critical value (2.045).

What implications for Earth science education and research may be drawn from the findings of this study?

The present study determined that Grade 11 students held generally positive perceptions about Earth science and that the majority of them attained average to above average performance in the subject. While students' perception about Earth science was found to be not significantly related to their achievement level, students themselves have identified factors that could have contributed to their appreciation of the subject.

Recognizing students' perception about their science classes may significantly improve curricular design and implementation (Bernardo et al., 2008). In addition, key insights may also be drawn from the results of the study that can improve teaching and research in school-level geoscience education.

To further strengthen students' interest in Earth science, science programs must incorporate real-world applications of geoscience (Jermyn et al., 2023). Citing recent events and relating them to the relevant Earth science concepts could deepen students' appreciation of how geoscientific knowledge informs major decisions and policies. Incorporating socio-scientific issues highlight the connection of science to everyday life and enhances students' awareness of its significance (Lansangan & Orleans, 2023). Authentic assessments, such as performance tasks, may also be designed to allow students to take on the role of researchers, government officials, and other stakeholders tasked to work on problems that mimic the most pressing issues of the community.

As in any discipline, effective and accurate delivery of Earth science lessons can lead to improved learning gains. When the right pedagogical approaches are used, students make sense of the terms and definitions studied in class, they understand and apply Earth science ideas more meaningfully, and they gain confidence in using mathematical and statistical approaches in learning Earth science. In the classroom, students develop critical evaluation of Earth science information through tasks that challenge them to cite their sources and fact-check materials found on the Internet. This can be implemented through activities such as brainstorming, group reporting, research writing, and other similar exercises.

To address the lowest percentage favorable score of the science and society category in the SPESS, interventions that help promote students' understanding of scientific activities and their interaction with media and government may be explored. These include visits to government and private institutions where students can personally interact with scientists and observe their work. Invited talks and webinars may also be organized to facilitate knowledge sharing with Earth science experts. Moreover, work immersion and internships provide opportunities to connect with practitioners and observe the day-to-day operation in scientific organizations. Emphasizing the relevance of science in future careers and in Philippine society may also help in developing students' performance in the subject (Bernardo et al., 2023).

Based on the results of the GCI subtest, Earth science topics that need to be revisited include the identification and characterization of rocks and minerals, geologic processes along plate boundaries, and the different techniques used in determining the age of the Earth. Recommended teaching strategies include the use of more hand specimens and the allotment of longer laboratory hours, as well as lesson reinforcement through direct instruction and independent learning activities. Practical tasks in geology, as seen in earlier studies (e.g., Celabe & Salinas, 2024), effectively enhance students' perception and interest in science. Additionally, students' problem-solving ability may be enhanced by providing activities that integrate real-life scenarios and mathematical skills. An example would be the triangulation method in finding the epicenter of an earthquake using the P-S wave arrival time data from three or more seismograms. Validated instruments measuring students' comprehension of geologic concepts, such as deep time (Dodick & Orion, 2003b), may likewise help identify alternative conceptions about the planet and serve as baseline for the development, implementation, and evaluation of Earth science lessons.

It must be noted that reinforcing Earth science instruction should not be limited to the senior high school curriculum. Strengthening foundational knowledge from grade school through junior high school prepares students for more complex lessons. In this study, questions about the Earth's interior and the evolution of the Earth's surface were answered correctly by the majority of students. These concepts were previously taught in junior high school, particularly in the preceding grade level (Grade 10).

Securing significant gains in Earth science education also requires teachers to continually improve their pedagogical and content knowledge. School administrators are enjoined to promote Earth science education by providing ample support for faculty development programs, capacity-building activities, and membership in professional organizations. Scholarship grants that will allow teachers to earn relevant graduate degrees can also boost the academic qualifications and credibility of Earth science teachers. A carefully designed master's program for Earth science educators, for instance, will enable them to upgrade their skills and teach the subject more effectively (Huntoon & Baltensperger, 2012).

As partners in the education of their children, parents can also support the promotion of Earth science through family activities, such as visits to libraries and museums. These informal learning environments allow the continuity of learning experience beyond the classroom. Household practices, such as waste segregation and disaster preparedness, can demonstrate practical application of students' knowledge on environmental awareness and natural Earth processes.

Further investigation into the factors affecting students' perceptions and achievement in Earth science may be taken up within other contexts, such as the type of school, teacher profile, and students' socio-economic background. Given that this study was conducted during the COVID-19 pandemic, it would also be interesting to conduct similar inquiries post-pandemic and observe any notable changes brought about by practices in the new normal. Future researchers may likewise consider employing a pretest-posttest research design and observe possible changes in students' perceptions and achievement level in Earth science before and after taking the course.

As an emerging arena of scholarly discussion, research in school-level Earth science education remains a fertile ground for scientific investigation and knowledge creation. Additional studies in this domain are crucial in establishing a robust knowledge base for future researchers. Nonetheless, the findings of the present study underscore the valuable contribution of Earth science education as a potent tool in developing the scientific knowledge, attitudes, and skills of students.

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