# Exploring the scientific conceptual understanding of intermediate-grade learners on Earth and Space

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## Abstract

*This research study aimed to determine the scientific conceptual understanding of Earth and Space Science among intermediate-grade learners at La Union, Philippines. A descriptive research design was utilized for 299 participants (146 males and 153 females, aged 9-12 years old) using a two-tiered multiple-choice type to measure the scientific conceptual understanding of the participants. The two-tiered test was subjected to the Rasch measurement model, which can resolve guessing problems and detect outliers who answer via guessing for reliability and validity. The data results indicated that more students "do not understand the concept" and have "misconceptions". The study found that the conceptual understanding of the pupils had significant differences in terms of grade level through Kruskal-Wallis H Test. However, a significant difference in conceptual understanding between gender in every grade level was not found using Mann-Whitney U Test. These findings highlight the importance of focusing on building a strong conceptual understanding of science in intermediate grades (4–6) by addressing foundational gaps to master science concepts and succeed.*

## Keywords

*Earth and Space Science, intermediate grade learners, misconception, scientific conceptual understanding*

## Résumé

*Cette étude vise à déterminer la compréhension conceptuelle des sciences de la Terre et de l'espace chez les élèves de niveau intermédiaire à La Union, aux Philippines. Un modèle de recherche descriptif a été utilisé pour 299 participants (146 garçons et 153 filles, âgés de 9 à 12 ans) en utilisant un questionnaire à choix multiples à deux niveaux pour mesurer la compréhension des concepts scientifiques des participants. Le test à deux niveaux a été soumis au modèle de mesure Rasch, qui permet de résoudre les problèmes de devinettes et de détecter les valeurs aberrantes qui répondent par devinettes, afin d'en assurer la fiabilité et la validité. Les résultats des données indiquent que davantage d'élèves «ne comprennent pas le concept» et ont des «idées fausses». L'étude a révélé que la compréhension conceptuelle des élèves présentait des différences significatives en termes de niveau scolaire grâce au test H de Kruskal-Wallis. Cependant, le test U de Mann-Whitney n'a pas révélé de différence significative dans la compréhension conceptuelle entre les sexes à chaque niveau scolaire. Ces résultats soulignent l'importance de se concentrer sur la construction d'une solide compréhension conceptuelle des sciences dans les classes intermédiaires (4-6) en comblant les lacunes fondamentales pour maîtriser les concepts scientifiques et réussir.*

## Mots-clés

*Sciences de la Terre et de l'espace, apprenants de niveau intermédiaire, idées fausses, compréhension conceptuelle scientifique*

### *Cite this article*

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## Introduction

Teaching elementary pupils scientific concepts for deep understanding poses one of the greatest challenges for teachers. Students must arrange information into a coherent scientific concept to demonstrate conceptual understanding. Students can draw links between science concepts and their experiences by creating links out of facts and concepts. Conceptual understanding enables students to go beyond mere rote memorization of information and make meaningful connections between intuitive and scientific notions (Kang & Howren, 2004). It is a crucial aspect of science education, which centers on student's ability to grasp and apply scientific knowledge, involving the construction of private understanding of public knowledge (Mi et al., 2020; Widiyatmoko & Shimizu, 2018).

To examine the scientific conceptual understanding (SCU) of the learners, Lengkong et al. (2021), presents three categories under SCU namely understanding the concept (UC), misconception (MSC) and not understand the concept (NC). Learners are able to understand the concept if they can provide the right answer to a question about a particular concept in science and give the correct reason or explanation for the answer. On the other hand, learners held misconceptions if they could answer a science-related question correctly but were unable to provide the correct justification for their answer, or vice versa. Lastly, learners do not understand the concept at all if they are unable to answer the question correctly and cannot provide a correct scientific explanation for their answer at the same time.

According to the study of Widiyatmoko and Shimizu (2018), since conceptual understanding is one of the fundamental competencies in science learning, it is an integral part of science concepts in terms of knowledge competencies. Students must therefore have a conceptual grasp to successfully learn science. However, NC and MSC are the categories of the student's responses in which its contents determine the factors hindering the learners in comprehending new accurate scientific ideas and concepts (Novak, 1988; Yağbasan & Gülçiçek 2003).

In the international context, one of the problems in the scientific conceptual understanding of the learners is the NC. According to Bulunuz and Jarrett (2009), participants' incorrect prior knowledge regarding the phases of the moon were more varied than their understandings of the other concepts in this study. The first concept that most participants shared and was inaccurate was that the Earth's shadow is the cause of the phases of the moon. The research findings are in line with those of Bulunuz and Jarrett (2010), Cabe Trundle et al. (2010), Callison and Wright (1993), and Parker and Heywood (1998). Another false presumption held by study participants was that phases are caused by the planets' shadows or by their alignment with respect to the moon.

At the Philippine context, Department of Education (2016) states that the science education's goal is to enhance students' scientific literacy in order for the learners to become well-informed, engaged citizens capable of evaluating and deciding critically on how to utilized the accumulated scientific knowledge in such ways that could positively affect the environment, society, or their health. Yet, according to Albano (2019), a news article writer in the Manila Times, the latest 2018 National Achievement Test (NAT) results for Grade 6 Level showed that the Grade 6 NAT had a negative trajectory in terms of the average mean percentage score nationally, with a score of 37.44. San Juan (2023), discovered that in the history of the DepEd's standardized test, the year 2018 NAT scores were the lowest in which sixth-grade pupils performed in comparison to the years 2013 (68.88), 2014 (69.79), 2015 (69.09), and 2017 (39.95). In addition, only the overall Mean Percentile Score (MPS) was disclosed in the 2018 NAT result. Hence, the latest NAT that showed its complete results data among aforementioned years was the year 2017. The 2017 NAT results indicates that among the covered subject areas of NAT which are Filipino, Mathematics, English, Science and Araling Panlipunan (Social Science), the highest MPS is from the subject of Filipino (53.41), followed by English (40.37), Araling Panlipunan or Social Science (40.30), Mathematics (34.75), and the subject of Science (30.94) as the lowest. The NAT 2017 result is consistent with the results from the year 2013 and 2015 where Science has the lowest MPS in all subjects while second to the lowest in the year 2014.

Misconceptions, on the other hand, refer to personal knowledge acquired through formal education or informal experiences that lack scientific relevance or significance (Allen, 2014). As cited in the study of Birgin and Baki (2009), misconceptions are commonly referred to as "intuitive theories" and are a natural component of the learning process. Human minds naturally generate theories based on their daily interactions and experiences, but it is evident that not all of these theories and ideas are accurate in light of the most recent research and knowledge in a particular field. Misconceptions may originate from a variety of sources, including books (Sule & Jawkar, 2019), teachers (Bektasli, 2016; Cabello & Topping, 2018), real-life experiences (Baldy, 2023; Ozdemir & Clark, 2007; Sewell, 2002), and religious perspectives (Brickhouse et al., 2000).

Over the past three decades, the misconceptions of the learners are one of the subjects of numerous studies in the scientific discipline of education. According to these studies, a lot of students arrive at science class with misconceptions that conflict with scientific principles or concepts (Posner et al., 1982). One of humanity's earliest sciences is astronomy. Research in astronomy education has grown significantly in recent years, focusing on various aspects of astronomical phenomena and student understanding. Despite this progress, there remains scarcity of research on astronomy education in early childhood and primary education levels (Blanco-Chamborro et al., 2023; Slater, 2018; Yatskiv & Vavilova, 2009). The field has evolved from sharing effective activities to systematically testing instructional methods using quantitative, qualitative, and mixed-method approaches. However, the connection between research and classroom instruction is often lacking (Bailey & Slater, 2003).

At the international scale, several studies found that fourth, fifth and sixth-grade pupils held misconceptions about Earth and Space Science (Laeli et al., 2020; Putri et al., 2021). A broad category of misconceptions concerns the phenomena of day-night alternation and phases of the moon including the earth and moon concepts. More specifically, the following have been mentioned: (1) the emergence of day and night where the Earth is the one that orbits around the Moon producing nighttime; (2) the moon is only visible at night; (3) the moon generate its own light (just like the Sun); (4) the moon stays on its place, fixed on its position, and do not rotate; (5) it only takes one day, 24 hours, for the moon to revolve around the Earth; (6) moon is relatively near the Earth, specifically a number of Earth-diameters away; (7) unlike the Earth, moon do not have gravity making things that dropped on the moon float "upward"; (8) dark regions are basins filled in with lava; (9) the exact same half appearance of the Moon remains illuminated in darkness; (10) phases of the moon occur due to the interplay between sunlight and the shadow reflected by the Earth to the moon's surface; (11) full moon happens when Earth blocks the Sun's rays, giving the Moon the appearance of a waning moon; (12) lunar eclipse takes place when the sun's light blocks the moon; (13) solar eclipse occurs when the Moon is behind the Earth, the Earth is in between the Moon and Sun, correspondingly creating a straight-line position; (14) full moon increases the number of births and the number of patients seeking mental care in an emergency department; and (15) werewolves were said to be humans that turned into wolves during the full moon (Hung et al., 2012; Smith et al., 2022; Syuhendri et al., 2022). Moreover, findings about the misconceptions regarding the Characteristics of the Star and Constellations were also identified in the studies of Agan (2004), Hung et al. (2012), Kurnaz (2016) and McClure & Machholz (2023) such as: (1) all kinds of stars are similar in color and size; (2) stars in a constellation are close to each other; (3) the sun is considered as the biggest star in the celestial body; (4) during the night, constellations move all over the sky; (5) North Star, Polaris, is the brightest star in the night sky; (6) our solar system contains only thousands of stars; (7) exact same stars are visible all throughout the year; and (8) stars in a constellation are arranged side by side.

In terms of national context, Chi (2023) reported that in the 2022 Program for International Student Assessment (PISA), only 23% of Filipino pupils achieved a basic competency in science. Accordingly, only one out of every four Filipino students taking the PISA 2022 exam was able to validate conclusions and "identify the correct explanation for familiar scientific phenomena". Moreover, there is a limited exploration of the misconceptions held by the Filipinos in the branch of Earth and Space Science. Most of the science studies that determines the misconceptions of the Filipinos focuses on other branches such as Biology (Rogayan & Albino, 2019), Chemistry (Abenes & Caballes, 2020), and Physics (Aligo et al., 2021; Jugueta et al., 2012).

In the local context, a face-to-face interview with the current and previous Grades 4 to 6 science teachers from the target schools of the study, the majority of teachers reported that their pupils frequently had misconceptions and do not understand the subtopics covered in Earth and Space Science.

An analysis of various tools for assessing learners' conceptual understanding was conducted to find the best method to measure misconceptions in intermediate-grade learners, and a review of their conceptual understanding measuring tools was conducted. Interviews (Bulunuz & Jarret, 2009; Cabe Trundle et al., 2010), open-ended tests (Ozkan & Akcay, 2016), multiple-choice tests (Lindell, 2001), and multiple-tier tests (Fadllan et al., 2019) were discovered to be the most common diagnostic tools. Multiple-choice test is widely used to measure students' understanding in large groups, but they may lower test reliability, lose clarity, complicate question design, misdiagnose misunderstandings, and student's may also give incorrect answers due to incorrect reasoning (Bassett, 2016; Chang et al., 2009; Goncher et al., 2016).

In order to address the problems associated with the standard multiple-choice examination, a two-tiered test system has been formulated and is being used as a diagnostic tool. This format, according to Adadan and Savaşçi (2012), consists of two tiers; the first tier consists of questions pertaining to a specific concept while the second tier is where students justify their answers. As a result, this design makes it possible to assess students' misconceptions (Tsui & Treagust, 2010). By employing Treagust's (1988) scoring method, we conclude that if both tiers are answered correctly the students have no misconceptions, while different answers to these tiers indicate misconceptions. While these tests were developed to particularly address the challenges that learners have with some science topics, the utilization of this testing strategy has gone global and has been applied across various subjects, including mathematics (Lin, 2016), biology (Balcı et al., 2006; Odom & Barrow, 1995), chemistry (Bayrak, 2013; Chiu et al., 2007), physics (Çil, 2015), natural science (Adodo, 2013; Chu et al., 2010), thermodynamics (Siswaningsih et al., 2017), genetics (Tsui & Treagust, 2010), programming languages (Yang et al., 2015), and astronomy (Kanli, 2015). Ultimately, such approaches facilitate student self-regulation by clarifying their conceptions of Earth and Space Science topics.

The results from this current research provided useful insights. Firstly, the exploration and identification of current scientific conceptual understanding on Earth and Space Science covered topics helped the learners become aware of the concepts and ideas that they know comprehensively, do not know, and have incorrect perceptions of. In this way, it might drive the pupils to recheck and correct their understanding, which promotes self-regulated learning.

Furthermore, to shed light on the abovementioned gaps, this study aimed to explore and determine the scientific conceptual understanding of intermediate grade learners in Earth and Space in La Union, Philippines. Specifically, the study sought to answer the following questions:

1. What is the conceptual category of the following grade levels:
   a. Grade 4,
   b. Grade 5 and
   c. Grade 6.

2. Is there a significant difference between the scientific conceptual understanding as to:
   a. grade level and
   b. gender?

## Materials and methods

### *Research design*

A descriptive research design was employed in this study to determine and describe the scientific conceptual understanding of the intermediate grade learners. Descriptive research design is very important since it can help with the creation of research ethics protocols, especially in the area of ethics (Doyle, 2020).

### *Sources of data*

The pupils at Balaoc Elementary School, Cabaruan Integrated School, and Tococ Elementary School in La Union, Philippines in the intermediate grade level (Grade 4, 5, and 6, respectively) served as the study's main sources of data. Participants in this study comprised 299 pupils, with the age range of 9-12 years old, 146 of whom were male and 153 of whom were female, through a total enumeration. While younger students (Grade 4) may have limited prior knowledge, older students (Grade 6) are likely more familiar with the topic due to the spiral progression approach of the curriculum, where the topics are first presented in the earlier grades and then rediscovered in more complex forms in the following grades.

### *Instrumentation and collection of data*

The scores of the learners on the two-tiered test instrument served as the primary source of data for this study (see https://drive.google.com/drive/folders/1EGTO2FBdglydS3dWoA3WluIrIqHC7Nsv?usp=sharing). The selected topics on Earth and Space Science which are covered for the experiment are the following: 1) Moon characteristics; 2) Moon phases; 3) Star characteristics; and 4) Constellation. The sequence and content of topics are designed and defined by the curriculum to meet the standards and learning outcomes, where the topics are first presented in the earlier grades and then rediscovered in more complex forms in the following grades, as magnified in a Spiral Progression Approach of their curriculum.

A 24-item two-tiered test covering the mentioned topics on Earth and Space Science was created by the researchers wherein each topic has six test questions. It was a multiple-choice type of test to cater remembering, understanding, applying, evaluating and creating skills of the learners under the Revised Bloom's Taxonomy. The test was administered as a paper-based exam. Students were allowed to refer back to previous questions. The researchers read the instructions aloud, and any questions were clarified before the test began. The figure I below was an example of a two-tiered test question:

**FIGURE 1**

Q. If I will throw a ball upwards on the Moon, what do you think will happen to the ball?

a. The ball will disappear in space.
b. The ball will easily fall down in the Moon in one second.
c. The ball will take about seconds longer before it will fall on the Moon's ground.
d. The ball will stay floating in the atmosphere and will never go down to the ground.

What is your reason for your answer to the previous question?

a. The Moon's gravitational pull is weaker compared to Earth.
b. The Moon's gravitational pull is equal to Earth.
c. The Moon's gravitational pull is stronger than Earth.
d. The Moon has no gravity, thus, things float up when dropped on the Moon.

*Example of two-tiered test question*

The set of questions was subjected to validity and reliability tests before being administered to the research participants. The test instruments were found to be "Highly Valid" (4.26) in the content validation result to expert validators, and "Good" (0.71) in the Cronbach alpha for reliability when pilot-tested. The index of discrimination and index of difficulty were also processed to further enhance the instrument by confirming that the test items' appropriateness and difficulty were appropriate for the grade level.

The reliability and validity of the test instrument were further examined through Rasch Analysis. Table I shows every item's measure, standard error (S.E.) measure, infit, and outfit. A data known as the S.E. Measure demonstrate how well sampled data represents the whole population. By measuring standard deviation, it assesses how closely a sample distribution reflects the population. In statistics, the standard error of the mean is the discrepancy between a sample mean and the actual population mean.

It implies that a sample is more representative of the entire population when the standard error is small.

**TABLE 1**

*Item Fit Analysis*

| Topic | | Measure | S. E. Measure | Infit | Outfit |
|---|---|---|---|---|---|
| Characteristics of the Moon | Q1 | -1.91 | 0.0509 | 1.268 | 1.268 |
| | Q2 | -1.38 | 0.0632 | 1.269 | 1.269 |
| | Q3 | -1.81 | 0.0522 | 0.913 | 0.913 |
| | Q4 | -1.74 | 0.0532 | 0.805 | 0.805 |
| | Q5 | -1.79 | 0.0524 | 0.891 | 0.891 |
| | Q6 | -1.71 | 0.0539 | 0.933 | 0.933 |
| Phases of the Moon | Q7 | -1.75 | 0.0531 | 1.050 | 1.050 |
| | Q8 | -1.57 | 0.0572 | 0.865 | 0.865 |
| | Q9 | -2.05 | 0.0501 | 1.078 | 1.078 |
| | Q10 | -1.72 | 0.0538 | 0.953 | 0.953 |
| | Q11 | -1.83 | 0.0519 | 0.861 | 0.861 |
| | Q12 | -1.94 | 0.0507 | 1.008 | 1.008 |
| Characteristics of the Star | Q13 | -1.87 | 0.0514 | 1.147 | 1.147 |
| | Q14 | -1.69 | 0.0542 | 1.015 | 1.015 |
| | Q15 | -1.26 | 0.0676 | 1.325 | 1.325 |
| | Q16 | -1.56 | 0.0573 | 1.119 | 1.119 |
| | Q17 | -1.90 | 0.0511 | 0.948 | 0.948 |
| | Q18 | -1.88 | 0.0513 | 0.885 | 0.885 |
| Constellation | Q19 | -1.60 | 0.0564 | 0.868 | 0.868 |
| | Q20 | -2.06 | 0.0501 | 1.315 | 1.315 |
| | Q21 | -1.64 | 0.0554 | 0.970 | 0.970 |
| | Q22 | -1.78 | 0.0526 | 0.899 | 0.899 |
| | Q23 | -1.74 | 0.0533 | 0.883 | 0.883 |
| | Q24 | -1.61 | 0.0561 | 0.839 | 0.839 |

A smaller standard error is therefore preferred. If the standard error is 0 or extremely close to it, the projected value equals the real value. Hence, based on the data under S.E. Measure, all 24-item have an S.E. of zero or close to it which indicate that the estimated values were exactly the true values.

Infit refers to the individuals who were more susceptible to unexpected trends in observations made by others about things that are often directed at them, and vice versa. On the other hand, outfit is more receptive to unanticipated remarks made by others on things that are exceedingly easy or extremely difficult for them (and vice versa).

Estimates of the infit and outfit items that fall between 0.50 and 1.50 show equal discrimination among the items and are useful for measuring. Because of this, all of the data in this study's infit and outfit categories fall between 0.50 and 1.50, indicating that there is equal discrimination across all items and suggesting that the data is useful for assessment.

**TABLE 2**

*Model fit based on Rasch analysis*

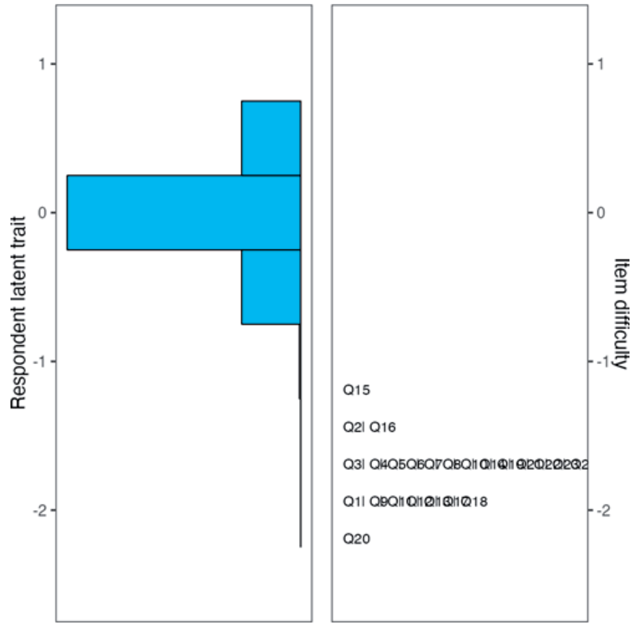
| | Pearson Reliability | MaDaQ3 | p |
|---|---|---|---|
| Scale | 0.403 | 0.0550 | 0.007 |

Table 2 shows the results of Pearson reliability, MADaQ3, and p-value. The MADAQ3 represents the effect size of the model fit wherein if the value is close to 0, it indicates a good model fit. Next, the p on the rightmost side of the table is the p-value, which states that if the value is less than the alpha level of.05, the model shows a good fit. Based on the result, since the value of MADaQ3 (0.06) is close to 0 and the p value is below.05 alpha level, this indicates that the model shows a good fit. It also implies that the data fit the model accurately.

Figure 2 shows the relationship between student ability and item difficulty in a right-item-person map. The left side of the figure presents the respondent's latent trait, which indicates the measured ability of the candidates. Pupils with higher levels of conceptual understanding at the top of the graph and pupils with lower levels of conceptual understanding at the bottom.

The right side of the figure, on the other hand, shows the item difficulty. The items are distributed from the most difficult at the top to the least difficult from the bottom. Hence, based from the result found, item 15 (What is the biggest star in the celestial body?) under the topic of the characteristics of the star is the most challenging to correctly answer. Meanwhile, item 20 (How many constellations are used for the zodiac signs, zodiac calendar, and astrology?) under the constellation topic is the easiest. This question was included as it was relevant because it bridges science, history, and culture, while also engaging students in critical thinking about the natural world and human beliefs. Likewise, the zodiac constellations are part of the broader study of astronomy, helping students understand the movement of celestial bodies and the structure of the night sky. However, because the items on the graph fell into the negative values, this implies that the respondents answered these items incorrectly.

**Figure 2**




*Wright item-person map*

**Table 3**

*Model fit based on Confirmatory Factor Analysis*

| CFI | TLI | SRMR | RMSEA | CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| 0.560 | 0.507 | 0.0545 | 0.0322 | 0.0215 | 0.0415 |

In addition, the Confirmatory Factor Analysis (CFA) shows the test instrument's construct validity, as seen in Table 3. The model proposed a single-factor CFA model with 24 items; this model showed acceptable goodness-of-fit indices. The results showed that all cut-off criteria values were met, all of which had a significant positive factor loading CFI = .560, RMSEA =.032, CI (.022, .042) and SRMR= .055. Thus, the single-factor model showed the best fit, indicating acceptability in terms of construct validity and achieving unidimensionality in a single factor.

***Ethical consideration***

The researchers submitted the study protocol, informed consent, and assent form to the Ethics Committee of the university to evaluate before starting the study. The university's Ethics Committee issued a certificate of exemption from review along with the RETC Code: 2024 -546. The respondents were provided with assent forms while their parents were given consent form to allow their child to participate in the study.

***Analysis of data***

To identify the scientific conceptual understanding of Grades 4, 5, and 6, Descriptive Statistics was used. Likewise, the normality test through Shapiro-Wilk Test was employed to determine whether a parametric test was used or a non-parametric. If the p-value is less than .05, then the data is normally distributed.

**TABLE 4**

*Test of normality*

| | | statistic | P |
|---|---|---|---|
| Conceptual Understanding | Shapiro-Wilk | 0.707 | <.001 |

Shapiro-Wilk test findings for normality are shown in Table 4, where a p-value of less than .001 indicates that there is unequal distribution of data. The p-value falls below the chosen significance threshold below .05. Thus, the data are thought to be non-normally distributed.

As a result, a non-parametric test was used since the data was not normally distributed. Hence, the Kruskal-Wallis H Test was employed to determine if there is a significant difference in the scientific conceptual understanding between the three grade levels, while the Mann-Whitney U Test was used to determine the difference in terms of gender using Jamovi (Version 2.5).

Furthermore, the means of three different groups were compared in order to ascertain whether the differences between the corresponding population means were statistically significant. If the p-value is below the significance level of .05, it implies that at least one population mean varies from the others. Four concept-based response choices (A, B, C, and D) comprise the first tier of this two-tiered test item. The second layer, on the other hand, contained four responses, or the justifications for choosing the answers in the first tier. For every item combination, students should answer the first and second tier or layer and their answers. The way the students answered each question in Table 5 determined how the responses were merged, analyzed, and interpreted.

**TABLE 5**

*Decision category based on the learner's combination of responses in the first and second tier*

| **Answer** (1st – tier) | **Scientific Reason** (2nd – tier) | **Decision Category** | **Coding** |
|---|---|---|---|
| Correct | Correct | Understand the concept (UC) | 3 |
| Incorrect | Correct | Misconception (MSC) | 2 |
| Correct | Incorrect | Misconception (MSC) | 2 |
| Incorrect | Incorrect | Not understand the concept (NC) | 1 |

Table 5 presents an examination of the set of responses categorized under the decision-making category about the students' conceptual comprehension, using the guidelines in UC, MSC, and NC.

## RESULTS

This section presents the findings obtained from the test instrument scores of intermediate-grade learners in Earth and Space.

### *Conceptual category of intermediate-grade learners*

**TABLE 6**

*Conceptual category of intermediate grade learners*

| | Grade 4 | | Grade 5 | | Grade 6 | | |
|---|---|---|---|---|---|---|---|
| Decision Category | f | % | f | % | f | % | **Total** |
| UC | 11 | 10 | 14 | 14 | 17 | 17 | **42** |
| MSC | 45 | 43 | 38 | 40 | 40 | 40 | **123** |
| NC | 48 | 47 | 43 | 46 | 43 | 43 | **134** |
| **Total** | **104** | **100** | **95** | **100** | **100** | **100** | **299** |

Table 6 and Table 7 present the results of the conceptual category in the covered topics of Earth and Space Science of the intermediate grade learners using the two-tiered test instrument.

Under the fourth-grade level, the descriptive statistics indicate that the majority of fourth-grade pupils in the selected schools have a decision category "NC" (*f*=48, %=47), followed by having "MSC" (*f*=45, %=43), and "UC" as the least conceptual category (*f*=11, %=10). This data implied that there is a gap and a need for improvement in the scientific conceptual understanding of the grade four pupils on Earth and Space science.

**TABLE 7**

*Student responses to each question*

| Type | | NC | MSC | UC | TOTAL |
|---|---|---|---|---|---|
| Characteristics of the Moon | **Q1** *Moon's orbit* | 135 | 80 | 84 | **299** |
| | **Q2** *Days of revolution* | 205 | 65 | 29 | **299** |
| | **Q3** *Moon's surface* | 119 | 143 | 37 | **299** |
| | **Q4** *Difference between rotation and revolution* | 114 | 158 | 27 | **299** |
| | **Q5** *Moon's visibility* | 124 | 146 | 29 | 299 |
| | **Q6** *Moon's gravitational pull* | 135 | 134 | 30 | **299** |
| Phases of the Moon | **Q7** *Moon's first phase* | 137 | 116 | 46 | **299** |
| | **Q8** *Creation of Solar Eclipse* | 147 | 133 | 19 | **299** |
| | **Q9** *Number of Moon's phases* | 96 | 120 | 83 | **299** |
| | **Q10** *Moon's changing appearance* | 131 | 131 | 37 | **299** |
| | **Q11** *Reason why Eclipse occur* | 109 | 154 | 36 | **299** |
| | **Q12** *Fact about full moon* | 108 | 131 | 60 | **299** |
| Characteristics of the Star | **Q13** *What is a star?* | 137 | 102 | 60 | **299** |
| | **Q14** *Sun as a star* | 140 | 118 | 41 | **299** |
| | **Q15** *Biggest star* | 214 | 56 | 29 | **299** |
| | **Q16** *Brightest star* | 175 | 94 | 30 | **299** |
| | **Q17** *Color of the star* | 107 | 142 | 50 | **299** |
| | **Q18** *Are all stars the same* | 102 | 152 | 45 | **299** |
| Constellation | **Q19** *Definition of constellation* | 143 | 136 | 20 | **299** |
| | **Q20** *Constellations used in zodiac calendar* | 124 | 74 | 101 | **299** |
| | **Q21** *Total number of constellation* | 147 | 123 | 29 | **299** |
| | **Q22** *Why constellations are moving?* | 123 | 145 | 31 | **299** |
| | **Q23** *Arrangement of stars in a constellation* | 123 | 144 | 32 | **299** |
| | **Q24** *Fact about constellation* | 142 | 141 | 16 | **299** |

Next, the data also indicates that most of the fifth-grade pupils in the selected schools have a decision category of "NC" (*f*=43, %=46), followed by having "MSC" (*f*=38, %=40), and "UC" as least conceptual category (*f*=14, %=14). This implied that under Earth and Space Science the fifth-grade pupils lack scientific conceptual understanding and need to improve.

On the other hand, under the sixth-grade learners, the data also displays that most of the pupils in the selected schools have a decision category of "NC" (*f*=43, %=43), followed by having "MSC" (*f*=40, %=40), and "UC" as the least conceptual category (*f*=17, %=17). This implied that in Earth and Space Science there is a need for improvement in the sixth-grade students' scientific conceptual understanding.

***Difference in the scientific conceptual understanding in terms of:***

a. Difference in the scientific conceptual understanding in terms of Grade Level

**TABLE 8**

*Difference in the scientific conceptual understanding in terms of grade level*

| | | $X^2$ | df | P |
|---|---|---|---|---|
| Conceptual Understanding | Kruskal-Wallis | 7.12 | 2 | .028 |

The researchers used Kruskal-Wallis Test to compare pupil conceptual category scores under UC, MSC, and NC, across grades 4, 5, and 6 pupils on the two-tiered test instrument. Table 8 displays the significant difference between the conceptual categories of grade 4, 5, and 6 pupils determined by the Kruskal-Wallis Test. A noteworthy disparity in students' conceptual comprehension of concepts related to earth and space science was noted $X^2(2)=7.12$, $p<.05$.

**TABLE 9**

*Dunn's post-hoc analysis*

| Groupings | Sig. | Adj. Sig. |
|---|---|---|
| 4 – 5 | .067 | .201 |
| 4 – 6 | .010 | .029 |
| 5 – 6 | .475 | 1.000 |

The scientific conceptual understanding of learners in grades 4 and 6 was significantly different from each other ($p$=.010, $p$=.029), compared to grades 4 and 5 ($p$=.067, $p$=.201) and between grades 5 and 6 ($p$=.475, $p$=1.000), further done by post-hoc comparisons performed using Dunn's method where .05 is the selected significance level, as shown in Table 9.

b. Difference in the scientific conceptual understanding in terms of Gender

**Table 10**

*Difference in the scientific conceptual understanding in terms of gender*

| Grade Level | Gender | n | U | p | Effect Size |
|---|---|---|---|---|---|
| Grade 4 | Male | 50 | 1123 | 0.086 | 0.168 |
| | Female | 54 | | | |
| Grade 5 | Male | 54 | 936 | 0.115 | 0.155 |
| | Female | 41 | | | |
| Grade 6 | Male | 49 | 1187 | 0.571 | 0.0504 |
| | Female | 51 | | | |

Mann-U Whitney Test was used to compare the decision category scores between male and female in each grade level. Table 10 presents that there is no significant difference between the scores of males ($n$=50) and females in the fourth grade level ($n$=54), $U$(103)=1123, $p$=.08, $d$=.17.

In terms of fifth grade, it was also found that there is no significant difference between the scores of males ($n$=54) and females ($n$=41), $U$(94)=936, $p$=.12, $d$=.16. Lastly, the sixth grade pupils was found also found to have no significant difference between the score of males ($n$ = 49) and the scores of female ($n$=51), $U$(99)=1187, $p$=.08, $d$=.05. This result was found to have small effect size.

## Discussions

This study sought to explore the scientific conceptual understanding of the intermediate grade learners in Earth and Space. Firstly, it was discovered that, out of the three grade levels, the majority of learners in the intermediate grade lack an understanding of the concepts and ideas in Earth and space science, despite the spiral progression of the curriculum where the topics are first presented in the earlier grades and then rediscovered in more complex forms in the following grades. This implies that topics are reintroduced without sufficient connection to prior learning (Diani et al., 2024), leading to fragmented understanding. This finding is in line with the research from Agata (2004), where ten-year-olds find it difficult to comprehend the moon's phases. About 40% of kids in grades 4 through 6 exhibit geocentrism and most of these learners do not know why the moon phases occur. Likewise, this finding is corroborated in the study of Plummer and Krajcik (2010) where elementary pupils lack understanding about the sun, moon, and stars. The findings about the conceptual category were followed by the pupils having misconceptions mainly in the concepts about the phases of the moon. This finding is in line with the research of Coş tu et al. (2022) where pupils have a number of misconceptions about the phases of the moon and the beliefs that surround it.

In terms of their grade levels, the pupils' conceptual understanding of science concepts appears to differ noticeably. Outcomes from the two-tiered test employed in the study show that students in the fourth, fifth, and sixth grades had considerably different levels of understanding. Moreover, Grade 4 and Grade 6 have significant difference, probably due to the spiral progression of the curriculum, but not for the consecutive grade levels. The data's conclusions are in line with numerous studies which indicate that there are differences in learner's conceptual understanding of science subjects throughout different grade levels. Moreover, Kang and Yoo (2018) observed that when presented with misunderstandings, elementary school pupils who have stronger scientific attitudes were more inclined to revise their scientific beliefs. In addition, Koerber et al. (2014), report that advanced conceptions rose while naïve conceptions fell with each grade shift. Furthermore, Prabha (2020) pointed out that students have a hard time grasping science topics.

The changes in instruction between grade levels, cognitive maturity, and cumulative learning experiences are some possible explanations for the result, despite the curriculum to be in spiral progression. The study emphasizes how crucial it is to modify the scientific curriculum to meet the various demands and comprehension levels of children in various grade levels. In addition to content, the method of teaching scientific concepts at each grade may also have a role to play. Further research could investigate the fundamental causes of these grade-level variations and assess how well-targeted teaching approaches improve scientific conceptual understanding at all grade levels.

In terms of their gender, the learner's conceptual understanding of science concepts showed no significant differences between their scores. The findings are consistent with Jia et al., (2020), which found no significant differences in gender regarding the conceptual understanding of science. Despite the degree of scientific knowledge, Hayes (2001) also found no significant disparity in views regarding the environment between men and women. Likewise, Shepardson and Pizzini (1994) found no evidence of statistically significant variations in science perception or achievement between genders. Furthermore, there were no discernible gender disparities in science performance or attitudes according to Lock (1992) and Greenfield (1996).

Similarly, research conducted by Wardani et al. (2023) demonstrated that students' understanding of the nature of science (NOS) was not influenced by gender biases, suggesting that both genders are equally capable of grasping scientific concepts when provided with appropriate educational frameworks.

Moreover, Türer and Kunt (2015) highlighted that while gender can influence attitudes towards science education, it does not necessarily affect the conceptual understanding of science among elementary students. This perspective is further supported by Canuto and Espique (2023), who argue that inclusive and diverse educational practices can enhance students' understanding of science, thereby diminishing the perceived gaps between genders.

The study's finding supports the idea that science education can be equitable and inclusive, with no inherent gender-based barriers to understanding science concepts which contribute to the broader discourse on gender equality in STEM fields, suggesting that efforts to close gender gaps in science education.

### *Limitations*

It is worth noting that the researchers focus only on the problem concerned with the conceptual understanding of the intermediate-grade learners in three selected public schools in La Union, Philippines, namely Balaoc Elementary School, Cabaruan Integrated School, and Tococ Elementary School. The sole goal of this study is to ascertain the scientific conceptual understanding of the learners in the selected topics of Earth and Space Science, such as moon characteristics, moon phases, star characteristics, and constellations. It is crucial to highlight that the study did not examine the causes or elements that influenced the learners' current conceptual knowledge.

## Conclusions

This study explored the scientific conceptual understanding of learners in grades four to six on Earth and Space Science. Findings indicated that there was a significant lack of conceptual understanding across the three grade levels, with majority of intermediate grade learners lacking a conceptual understanding of Earth and Space Science. Additionally, it was discovered that a small percentage of students comprehended astronomy subjects and that some students had misconceptions about science concepts. However, the outcome does not demonstrate a significant difference in the scientific conceptual understanding of intermediate grade learners on Earth and Space based on gender.

These findings imply the need for the effectiveness of certain methods of instruction in promoting academic progress, emphasizing the significance of ongoing research and the development of instructional strategies to maximize learning outcomes for learners. Moreover, implementing teaching strategies tailored to the specific learning needs of each grade level is also necessary (Ravanis & Boilevin, 2009). This could involve varying the complexity of the content, providing targeted scaffolding for younger students, and offering enrichment opportunities for advanced learners. Likewise, mapping out key concepts and skills students should develop at each level builds upon prior knowledge. These findings highlight the importance of focusing on building a strong conceptual understanding of science in intermediate grades (4-6) by addressing foundational gaps to master science concepts and succeed.

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