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RESEARCH ARTICLE

Unveiling Argumentation Skill Profiles: Using Toulmin's Argumentation Model on Senior High School Students' Responses to General Biology Open-Ended Questions

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논증 기술 프로필 공개: 일반 생물학 서술형 질문에 대한 고등학생의 답변에 툴민의 논증 모델 적용하기

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ABSTRACT

In the pursuit of effective scientific communication, scholars employ argumentation—an idea-anchoring process using reliable evidence. This study focuses on nurturing scientific argumentation skills among 280 high school students in the Philippines, specifically in general biology, using Toulmin's model. Participants from Bayambang National High School responded to a 15-item open-ended questionnaire; six items were used for Toulmin's analysis, categorizing responses into five levels. Using Chi-square tests, we explored associations between response distribution, grade levels, and gender differences. Results show a correlation between grade levels and argumentation proficiency, notably 12th-grade students in levels 4 to 5. No significant gender-based differences emerged, indicating fairness in argumentation skills. Emphasizing the positive impact of integrating argumentation and scientific literacy in fostering critical thinking, Toulmin's model for daily science assessments is recommended. Effective teacher questioning and dilemmatic queries stimulate diverse thinking. Educators defining criteria for a "good" argument and providing targeted instruction for students' proficiency are pivotal. Studying formative assessment in Philippine biology refines practices, informs academia, and supports an inclusive education system for educators and policymakers, recognizing the dynamic nature of argumentation skills.

Key words: Scientific argumentation, Toulmin argumentation, high school, gender differences, formative assessment strategies, biology education in the Philippines

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Introduction

The development of critical thinking abilities and good communication is essential in today's dynamic educational environment, particularly in the field of science education. One essential talent for students in the twenty-first century is the capacity to argue scientifically. In addition to developing their critical thinking skills, it also helps them understand complex global challenges, which will enable them to make educated judgments as future leaders (Evagorou & Osborne, 2013; Trilling & Fadel, 2009). Although scientific argumentation is important, students frequently struggle to become proficient in it. The lack of experience and exposure to argumentation in the classroom is a major factor contributing to this problem (Bathgate et al., 2015).

Scientific argumentation is vital for students, as it teaches them to underpin their ideas with evidence, a core element of the learning process (Kuhn, 2010). In our research, we concentrate on the context of high school education in the Philippines, specifically targeting students in grades 11 and 12. Our primary objective is to examine how these students employ the Toulmin Argumentation Pattern within the domain of general biology. To achieve this, we have administered open-ended questions that prompt students to engage in argumentation. By closely scrutinizing their responses, we aim to unravel the multifaceted ways through which students employ this argumentative framework. Additionally, we intend to formulate argumentation skill profiles that encapsulate the distinct strategies and methods employed by students in constructing their arguments. Furthermore, our investigation seeks to identify potential distinctions and commonalities in argumentation strategies between students in these two grade levels (Evagorou & Osborne, 2013; Lin et al., 2012).

By delving into how students in the Philippines employ the Toulmin Argumentation Pattern, we aim to contribute to the development of critical thinking skills in science education, thereby bolstering students' capabilities in grappling with complex scientific concepts (Osborne, 2010). As we navigate this academic terrain, our aspiration is to make meaningful contributions to science education not only within the Philippines but also on a broader, global scale. Our research is inspired by the recognition that nurturing argumentation skills is essential for preparing students for a future where informed decisions and scientific literacy are paramount (AAAS, 2008). By understanding how students in the Philippines engage with the Toulmin Argumentation Pattern, we hope to empower them with the tools required to think critically, reason effectively, and communicate persuasively within the realm of science and beyond (DOST, 2018; Kuhn, 2010).

In summary, our study seeks to unveil argumentation skill profiles among senior high school students in the Philippines. By focusing on the use of the Toulmin Argumentation Pattern, we aim to contribute to the development of their critical thinking skills within the domain of science education. Our research has the potential to not only enhance the educational experiences of Filipino students but also make valuable contributions to the broader field of science education, emphasizing the importance of fostering scientific argumentation abilities in the 21st century.

Related Literature

Scientific Argumentation in Education

Scientific argumentation stands at the forefront of contemporary science education, highlighting the development of critical thinking, problem-solving, and effective communication skills, as illustrated by Jiménez-Aleixandre and Erduran (2007). Simply put, scientific argumentation involves the complex procedures of creating, evaluating, and conveying scientific explanations and arguments (Driver et al., 2000). This multifaceted approach enables students to develop a thorough understanding of scientific concepts by allowing them to actively participate in the scientific method in addition to acquiring scientific knowledge (Osborne et al., 2004). A fundamental advantage of engaging scientific argumentation into educational frameworks is its capacity to immerse students in realistic scientific practices. Sampson, et al. (2011) believe that this immersive experience goes beyond passive learning, inviting students to become fully engaged in the dynamic realm of science through active engagement in the creation and examination of scientific arguments. A true enthusiasm for science and a strong sense of ownership over the learning process are fostered by this kind of involvement, which is also important for improving long-term retention.

Educators in science education have observed positive outcomes in integrating argumentation and scientific literacy. Primarily, this approach is essential in enhancing rational thinking (Bricker & Bell, 2008; Erduran & Jimenez-Aleixandre, 2008). Furthermore, the importance of scientific reasoning goes beyond academic boundaries, developing into a critical competency in a time of information overload. It equips students with the critical thinking and evidence-based decision-making abilities that are increasingly crucial in addressing the complex problems of the twenty-first century (McNeill & Krajcik, 2008). In essence, the integration of scientific argumentation in education acts as a pivotal channel, bridging scientific knowledge with real-world problem-solving, thereby boosting scientific literacy and equipping students to navigate the complexities of contemporary life with judgement and perceptiveness.

Proficiency in argumentation ability depends on students' capability in identifying and selecting reliable evidences while explaining how these evidence strengthen their position. According to Kuhn and Udell (2003), children exhibit competence in formulating claims and comprehending argument structures, and further, progressing to the evaluation of arguments at the collegiate level. Additionally, Felton and Kuhn (2001) observe that adolescents tend to prioritize arguments favoring their own position, and tend to neglecting opposing viewpoints. In contrast, adults, while advancing their arguments, are inclined to address opponents' positions through counterarguments. Notably, the development of argumentation skills may pose challenges for older students and may not fully develop until adulthood unless appropriate support is provided (Song et al., 2023). Furthermore, the conventional learning approach, characterized by the unidirectional delivery of content from teacher to students, rather than fostering activities that encourage communication and information exchange among students, can intensify the difficulty of cultivating effective argumentation skills.

Numerous studies have raised questions regarding the potential influence of gender on students' argumentation abilities performances. A comprehensive analysis of the existing literature reveals inconsistent findings concerning the impact of gender on students' argumentation performance (Jeong & Davidson-Shivers, 2006; Noroozi et al., 2022). Jeong and Davidson-Shivers (2006) found no significant gender differences in the number of critiques posted in response

to arguments. In contrast, Noroozi et al. (2022) observed that females significantly outperformed males in overall argumentative essay writing, particularly in expressing positions on specific topics. However, no significant differences were found in other aspects, such as constructing arguments, counter-arguments, justifications, responses to counter-arguments, and conclusions. Recent literature continues to explore the intersection of gender and scientific argumentation (Banihashem et al., 2023; Hasnunidah & Wiono, 2019; Noroozi et al., 2022). One significant motivation for this research stems from reported major differences in cognitive abilities between men and women, including higher verbal abilities favoring women, higher spatial abilities favoring men, and higher arithmetical abilities favoring men (Ardila et al., 2011). Moreover, distinct communication styles have been identified between men and women in argumentation. Men are more likely to assert opinions strongly as facts, prioritize expository styles, use crude language, violate online rules of conduct, engage in adversarial exchanges, and may terminate discussions during disagreements (Fahy, 2002). On the other hand, women tend to hedge, qualify, and justify their assertions using words such as "maybe," "possibly," and "perhaps." They express support for others, make apologies, and generally exhibit a consensus-making orientation and an epistolary style (Jeong & Davidson-Shivers, 2006). However, it is essential to note that overall findings in gender differences in argumentation ability were varied in the literature. The majority of students engage in argumentation practice through activities involving the writing of argumentative texts, providing a context in which gender association may be more noticeably identified.

Toulmin's Argumentation Pattern (TAP)

Toulmin's Argumentation Pattern (TAP) stands as a foundational tool for dissecting and refining arguments, offering a nuanced framework that is pivotal in assessing and enhancing argumentative abilities. Erduran et al. (2004) endorse TAP's utility, emphasizing its effectiveness in measuring argumentative skills, particularly in the academic realm. Toulmin's definition of argumentation introduces six integral elements, each playing a crucial role in constructing and evaluating persuasive discourse. The claim, representing the core assertion, is supported by grounds – specific facts providing a foundational basis. The warrant acts as the bridge, justifying the logical connection between the claim and grounds, while qualifiers add nuance to the claim's strength or certainty. Backing encompasses generalizations supporting the warrant, and rebuttals address exceptional circumstances that may challenge supporting arguments. Although strict adherence to Toulmin's argument pattern may pose challenges, its enduring popularity attests to its efficacy in characterizing argument structures (Erduran et al., 2004; Erduran, 2008).

In tandem with Toulmin's framework, Erduran et al. (2004) propose an analytical hierarchy categorizing argumentation into five levels, each providing unique insights into argument depth and complexity.

Level 1: Present a claim only.

Level 2: Present a claim and data and/or warrant.

Level 3: Present a claim, data, warrant and backing/qualifier/rebuttal.

Level 4: Present a claim, data, warrant, backing, and qualifier/rebuttal.

Level 5: Presents all components of argumentations: claim, data, warrant, backing, qualifier and rebuttal.

These levels range from presenting a basic claim to incorporating all essential components of argumentation. Sampson

and Clark (2009) highlight the significance of this analytical framework, suggesting a structured approach to evaluate the extent and quality of scientific argumentation within educational contexts. This analytical framework not only facilitates testing the effectiveness of argumentation but also guides the improvement of teaching methods. Significantly, it aligns with the broader objectives of contemporary science education, contributing to the central goal of nurturing critical thinking skills and enhancing the quality of scientific reasoning (Jiménez-Aleixandre & Erduran, 2007). The integration of Toulmin's Argumentation Pattern into the classroom transcends traditional knowledge delivery, pushing educators beyond boundaries. It aids in understanding science, raising a generation of sharp critical thinkers and skilled problem solvers. This integration highlights the paramount importance of scientific argumentation in contemporary science education, showcasing its transformative impact on the next generation.

Argumentation Framework in the Philippine Education System

In the Philippines, the education landscape is witnessing a transformation aimed at nurturing scientifically, technologically, and environmentally literate individuals' expert in critical thinking, problem-solving, environmental responsibility, effective communication, and innovation. The heart of this transformation lies in the argumentation framework integrated into the curriculum, especially in science education. The curriculum emphasizes inquiry-based learning, where students not only grasp scientific content but also develop the ability to construct well-reasoned arguments grounded in evidence, aligning with the Official Gazette of the Republic of the Philippines (n.d., p.2). This pedagogical shift is reinforced by teachers who utilize dialogic prompts tailored to students' developmental stages, thereby fostering an environment where students actively engage in constructing arguments. These dialogic prompts are instrumental in guiding the transition from subject understanding to more advanced stages of critical thinking.

The Department of Education (DepEd, 2017) has introduced an Alternative Learning System strand with competencies sequenced logically, from simple to complex, concrete to abstract, familiar to unfamiliar, and specific to general. This approach is strategically designed to enable students to apply critical thinking skills and problem-solving skills in their daily lives. In this context, critical thinking skills and scientific reasoning are integral components within the argumentation framework, as demonstrated by Giri and Paily (2020), who found that the effect of scientific argumentation positively contributes to the development of critical thinking.

While the Philippines attempts to enhance scientific argumentation skills, challenges related to performance in science, as noted by Farrington et al. (2012), persist. These challenges extend beyond academic achievement and may include factors such as school quality, family characteristics, socioeconomic status, and parental education levels. Addressing these multifaceted challenges requires an integrated approach that emphasizes the continued development of scientific reasoning and argumentation skills within the education system. A well-structured argumentation framework not only equips students to excel in local and global contexts but also instills in them the ability to think critically and reason effectively, contributing to the broader educational goals of the nation.

General Biology Education in the Philippine High Schools

The landscape of science education in the Philippines has undergone a transformative evolution, notably with the implementation of the K to 12 curriculum in 2012. This significant revision was prompted by the Philippines' challenges

in international assessments such as the Trends in International Mathematics and Science Study (TIMSS) in 1995, 1999, and 2003, revealing a need for reform to keep pace with global standards. As a response, the K to 12 curriculum aims to address these gaps and redefine science education in the country (Tirol, 2021).

The current curriculum in the Philippines reflects the Spiral Progression of learning science, a pedagogical framework pioneered by Jerome Bruner in 1960. Bruner's emphasis on aligning content selection with students' levels and presenting it in a structured and progressively complex manner has shaped the success of educational programs. This approach involves evaluating the relevance of information and its capacity to enable individuals to become better adults. The introduction of the K to 12 Basic Education Curriculum ushered in a new era for Philippine education, particularly in high schools. The two-year Senior High School, divided into various academic and non-academic strands, marked a departure from traditional learning and instruction. The Spiral Progression approach, where major topics per subject become more complex as students progress from Grade 1 to Grade 10, fosters continuous learning across grade levels. Interestingly, Spiral Progression is not required for both Grades 11 and 12.

The Department of Education (DepEd) Curriculum Guide serves as the blueprint for subject instruction, providing crucial details such as Subject Title, Grade level, Quarters for teaching, hours per quarter, subject description, course outline, code book legend, and references. The Senior High School Biology 1 and 2 curricula, uploaded at www.deped.gov.ph retrieved in August 2019, focus on the Science, Technology, Engineering, and Mathematics (STEM) Strand. Each course has a 40-hour allocation per quarter.

General Biology 1, taught in Grade 11, delves into the principles and concepts of biology, emphasizing life processes at the cellular and molecular levels, along with the transformation of energy in organisms. In Grade 12, students engage with General Biology 2, designed to enhance understanding of heredity and variation, diversity of living organisms, their structure, function, and evolution. Research studies examining the impact of the new Science curriculum in the Philippines on students' science concept formation, acquisition of scientific skills, and development of values or attitudes are perceived as highly relevant by students (Montebon, 2014). The Spiral Progression Approach significantly influences the Science curriculum, particularly in four science areas: Earth Science, Biology, and Physics, as revealed in a study by Resurreccion and Adanza (2015).

This evolving landscape reflects the Philippines' commitment to providing a robust science education that prepares students for the challenges of the 21st century.

Argumentation in the Philippine Science Classroom

In the Philippines, argumentation has come to be seen as essential to science education, following international trends that place an emphasis on scientific reasoning and critical thinking (DepEd, n.d.). By introducing argumentation into the K–12 Science Curriculum, the Department of Education (DepEd) has been a leading force behind this shift. High school students are required by this curriculum to participate in scientific reasoning, with an emphasis on the creation of arguments that are logically sound and supported by evidence. This approach emphasizes the importance of argumentation in science education and aligns with the national goal of developing scientifically literate citizens (DepEd, n.d.). Filipino science educators have embraced the importance of argumentation in science learning. They employ

pedagogical strategies and tailored dialogic prompts that encourage students to actively participate in constructing well-reasoned arguments (Andone & Hernandez, 2019). This commitment to argumentation aligns with international standards like the Next Generation Science Standards (NGSS) (NRC, 2012).

The Philippines is becoming more aware of the benefits of argumentation in the field of science education. Research carried out in the Philippines provides evidence of the beneficial effects of argumentation on science instruction, highlighting its function in fostering students' capacity for critical thought and reasoning. The Asia Pacific Journal of Educators and Education published a study by Imam, Mastura, Jamil, and Ismail in 2014 that sheds light on the relationship between science performance and reading comprehension abilities in the Philippines. Their results highlight how important it is for students to be able to think critically and reason, as this is the foundation of good argumentation (Imam et al., 2014).

The Department of Science and Technology (DOST) has advocated for the inclusion of argumentation in science classrooms, emphasizing that engaging students in activities such as scientific observations, experimentations, and argumentations can brighten the class and create more innovation (DOST, 2018). The DOST's advocacy underscores the practical benefits of argumentation in science education. The American Association for the Advancement of Science (AAAS) underscores the significance of students' ability to reason from evidence and participate in scientific argumentation as a major objective of science education reform (AAAS, 2008). This international perspective reinforces the importance of argumentation in preparing students for both local and global success.

Fundamentally, a growing body of research, educators' dedication, and DepEd's activities are all contributing to the increasing significance of argumentation in Philippine science classrooms (Antonio et al., 2021; Hernandez, 2019; Manolito, 2016). Although research highlights its advantages, resolving issues is still necessary to ensure its continuous integration and students' acquisition of critical 21st-century skills.

Research Aims

In this study, our primary goal is to delve into how Filipino senior high schools from grade 11-12 students of make use of the Toulmin's Argumentation Pattern components within the realm of general science by thoroughly investigating their responses to a specific open-ended question, we aim to uncover a variety of ways in which students apply this argumentative framework. Furthermore, we endeavor to create argumentation skill profiles that encapsulate the distinctive methods and tactics employed by these students in constructing their responses. These profiles will serve as valuable insights into their argumentative abilities and styles. Additionally, we seek to explore potential connections or correlations between these argumentation skill profiles, aiming to identify any overarching patterns or associations that may emerge.

Research Questions

RQ1. How is the typical argumentation profile in the general biology concept test among Philippine students with different level?

RQ2. How is the typical argumentation profile in the general biology concept test among Philippine students concerning the gender differences?

Research Methodology

General Background

This study applied quantitative methods to collect data from Bayambang National High School in Bayambang, Pangasinan, Philippines on open-ended questions in General Biology. During the 2022-2023 school year, the survey was used.

Participants

The research data were gathered from a total of 280 senior high school students at Bayambang National High School (BNHS), comprising nine classes—four from Grade 11 and five from Grade 12. These students, having been briefed about the research's objectives, willingly provided their consent to participate. All participants were enrolled in General Biology classes during the specified school year. To provide more specificity, Grade 11 students were exposed to General Biology 1, which explores the principles and concepts of biology, emphasizing life processes at the cellular and molecular levels, as well as the transformation of energy in organisms. In Grade 12, students delved into General Biology 2, a curriculum designed to deepen understanding in areas such as heredity and variation, the diversity of living organisms, and their structure, function, and evolution. Notably, despite the advanced exposure of Grade 12 students to General Biology 1, their responses to the 15-item open-ended questionnaire, facilitated by a General Biology teacher in the Senior High Department, were included in the study. It is essential to underscore that the questionnaire itself was meticulously crafted to align with the content covered in General Biology 1, ensuring relevance and coherence. This approach enabled the collection of meaningful insights from both Grade 11 and Grade 12 students. In terms of gender distribution, the sample comprised 206 female participants (73.6%) and 74 male participants (26.4%). Further demographic breakdown revealed 133 students (47.5%) from Grade 11 and 147 students (52.5%) from Grade 12. Understanding this demographic context is crucial for interpreting the study's findings, particularly within the broader educational dynamics of the Philippines' English-medium instruction system, as outlined by Gonzalez (2003).

Instrument and Procedures

For the purpose of this research, a subset of six specific questions was meticulously chosen from an original set which is a 15-item open-ended questionnaire. These questions were intentionally designed to prompt students to structure their responses in close alignment with the Toulmin Argumentation Pattern, fostering an exploration of critical thinking. The selected queries challenged students to delve into topics such as comparing cells to factories, understanding the role of the nuclear membrane in the endomembrane system, and investigating the functions of lysosomes, ribosomes, microbes, and the classification of viruses as living organisms. The original 15-item questionnaire, crafted by a General Biology teacher within the Senior High School department, provided a comprehensive means of exploring students' understanding. This instrument was added by a confidence level scale, enabling students to self-assess their responses, and a rubric to guide the assessment of their answers. The strategic decision to concentrate on six specific questions from the original set was made to align with the specific goals of this study, ensuring a focused analysis that directly addressed the research objectives. (Table 1)

Table 1. List of collected data

Item	Questions
Item 1	*How do you compare a cell to a factory?*
Item 2	*Is the nuclear membrane part of the endomembrane system? Why or why not?*
Item 3	*Why are lysosomes known as the cleaners of the cell waste?*
Item 4	*You already know those ribosomes are abundant in red blood cells. In what other cells of the body would you find them in great abundance? Why?*
Item 5	*Explain why not all microbes are harmful.*
Item 6	*Can we consider virus as living organism?*

Students' written responses to these selected questions were collected in a traditional paper-and-pen test format, and subsequently transcribed into a digital format using Google Forms for efficient data handling. The analysis of these responses involved a comprehensive evaluation of how well students incorporated the components of the Toulmin Argumentation Pattern in their answers. Multiple independent raters, two researchers involved in the study, meticulously assessed these responses to ensure reliability. The interrater reliability was quantified using Cohen's Kappa statistic, resulting in a value of 0.56, indicating a moderate level of agreement based on Landis and Koch's classification from 1977. In addition to reliability measures, descriptive statistics were employed to identify the specific components of the Toulmin Argumentation Pattern most frequently utilized by the students. This detailed analysis shed light on the proficiency of the students, as demonstrated by their application of the Toulmin Argumentation Pattern to the selected biology questions. The process provided valuable insights into the argumentative skills of students within the context of biology.

Data Analysis

Our data analysis was thoroughly designed to investigate the typical argumentation profiles among Philippine students on the general biology concept open-ended test, categorizing them based on the five distinct levels of argumentation (Erduran et al., 2004). We initiated the analysis by categorizing argumentation components in each response, and then calculating the frequencies of argumentation levels for grade 11 and grade 12 students, providing valuable insights into their predominant argumentation proficiencies. Descriptive statistics were instrumental in generating frequency distributions, offering a visual representation of how argumentation levels were distributed across different academic levels. The distributions of responses in each argumentation level were further analyzed based on grade and gender through Chi-square test using SPSS version 26. This statistical approach enabled us to investigate whether distribution of responses in argumentation level significantly associated to grade and gender differences. The results from these comparisons offered critical insights into the impact of academic level and gender on students' proficiency in conveying scientific arguments and enhancing our holistic understanding of the factors shaping argumentation skills among Philippine students. These analyses collectively laid the foundation for our subsequent discussions, where we will explore the implications and the multifaceted factors influencing the development of argumentation skills in the context of the general biology concept test among Philippine students.

Results

There are a number of students requiring support in refining their argumentation skills, as indicated by the prevalence of level 1 argumentations where the constructed claim was lacking extended rationale. Meanwhile, a substantial number of students manifest proficiency in constructing claims supported by warrants or empirical data, evident in a notable proportion advancing to level 2 of argumentation. Table 2 illustrates instances of arguments formulated by students in responses to item 6, centering on the probing question *"Can we consider virus as living organism? Why or why not?"*

Table 2. Example of arguments constructed by students

Argumentation Level	Argument Examples
Level 1	*"Viruses are not living things [Claim]."*
Level 2	*"No [Claim], because virus can't reproduce by themselves [Warrant]"*
Level 3	*"No [Claim]. Although viruses are complex assemblages of components, including proteins, nucleic acids, lipids, and carbohydrates [Data], they are powerless [Warrant] until they reach a living cell [Qualifier]."*
Level 4	*"Viruses are not living things [Claim]. Viruses are complicated assemblies of molecules, including proteins, nucleic acids, lipids, and carbohydrates [Data], but on their own they can do nothing [Warrant], until they enter a living cell [Qualifier]. Without cells, viruses would not be able to multiply [Backing]. Therefore, viruses are not living things"*
Level 5	*"Most biologists [Qualifier] say no [Claim]. Viruses are not made out of cells [Warrant], they can't keep themselves in a stable state, they don't grow, and they can't make their own energy [Backing]. Even though they definitely replicate and adapt to their environment [Rebuttal], viruses are more like androids than real living organisms [Data]."*

Responses from students that demonstrated an extension of their claims, supported by comprehensive justification, were considered as higher-level arguments. At the utmost tier, students have acknowledgment of alternative valid perspective of the situation. Constructing a rebuttal reflects a student's awareness of potential weakness in their claim, which, as it transpires, may contribute to enhance the overall strength of an argument, if they can defend their position with rational justifications. The analysis of argumentation profiles of the students across six distinct items revealed noteworthy trends (See Figure 1). According to grade level, overall argumentation level varies in each item, showing that students were mostly distributed in the Level 1 to Level 3 of argumentation, but rarely distributed in the higher (Level 4 and Level 5) levels of argumentation. In Item 1, both grade levels predominantly exhibited Level 1 argumentation, with a slight advantage for grade 12 students. Among three of the six items (item 2, item 3, and item 5), over than half of subject responding the general biology conceptual task with Level 2 argumentation, with common advantage for grade 12 students except for item 5. In Item 5, grade 11 students showcased robust Level 2 argumentation, while grade 12 leaned toward Level 3. In most cases where Level 3 of argumentation were found, grade 12 students excelled the grade 11 students except on item 2. In item 6, particularly when Level 4 and Level 5 of argumentation were found, grade 12 students demonstrated more comprehensive argumentation, showing at least one-fifth of students have formulated argument with rebuttal, which suggest a proper ability in supporting their claim with appropriate justification.

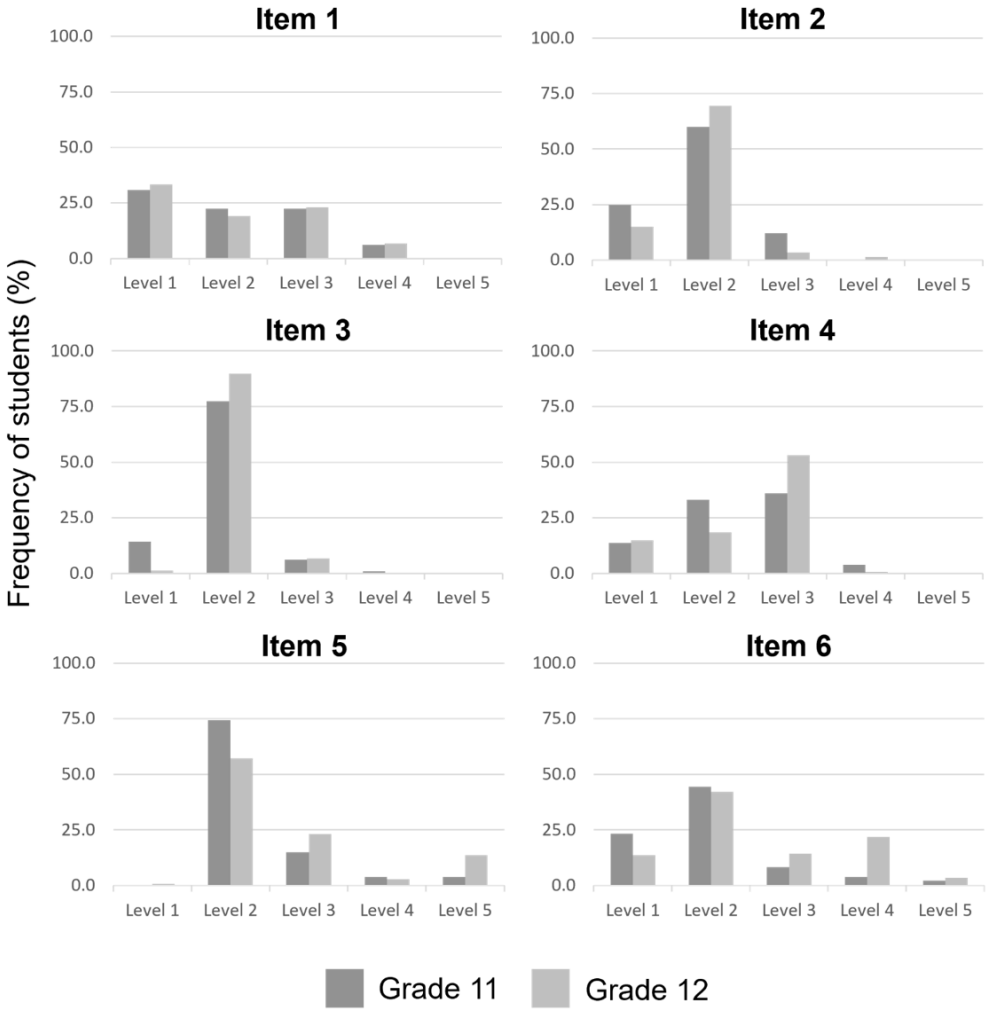

Fig. 1. Distribution of students' argumentation level according to grade

Besides the grade or level differences between the students. Analysis on argument formation was also observed among gender variable (Fig. 2). According to Figure 2, overall, only slight differences of gender on the arguments' distribution found. Students who were distributed in Level 1 argumentation in most cases were relatively dominated by female in five of the six questions. Similarly, among responses of level 2 argumentation, frequency of female students also excelled male students in most of items except for item 1 and item 2. The level 5 of argumentation are rarely found in item 1 to item 4, while gender distribution domination in the level 3 and level 4 of argumentation varies.

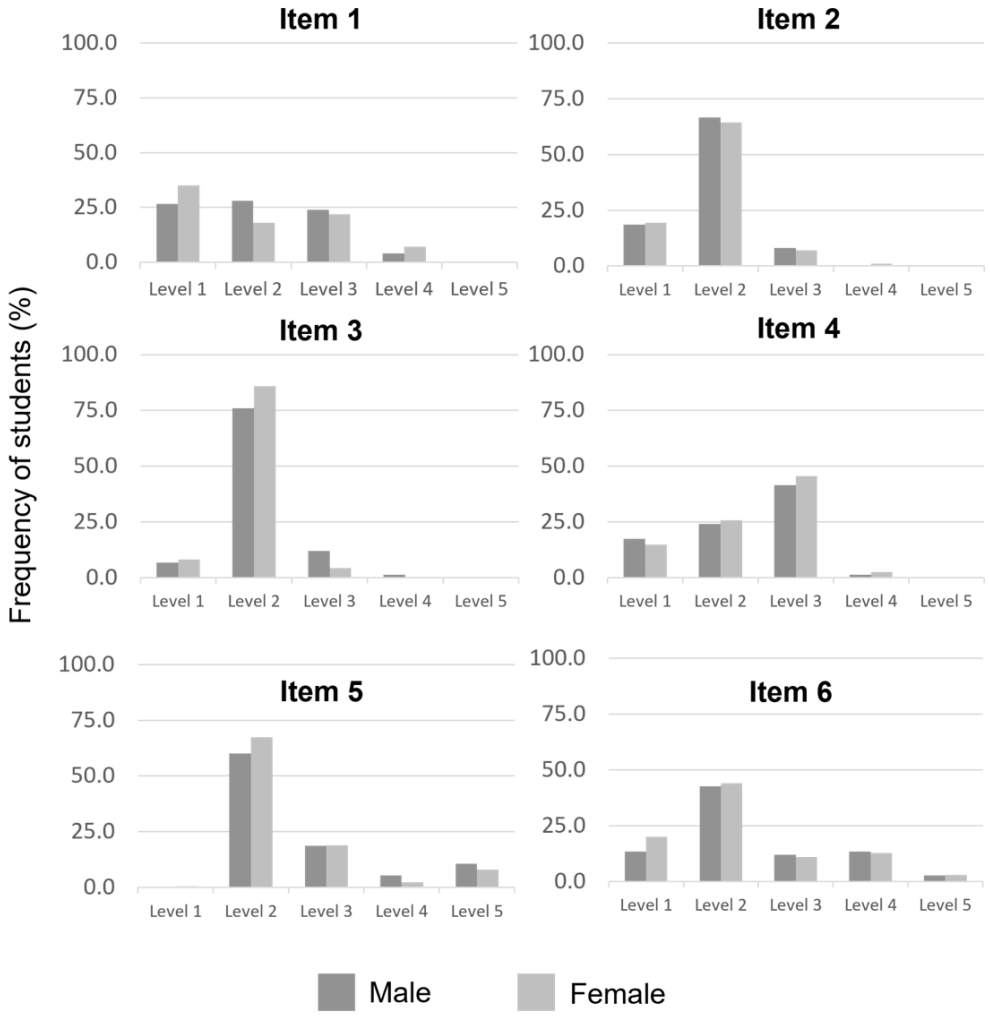

Fig. 2. Distribution of students' argumentation level according to gender difference

Further analysis was done by examining the comparison of overall achievement of general biology conceptual test based on gender and level (Table 3). The independent t-test yielded a slight advantage in male students with a p-value of 0.80 which suggested that there is no statistically significant differences in the general biology conceptual test scores between male and female students. In terms of grade or level difference, there is a significant difference in the conceptual test between students in Grade 11 and Grade 12, with Grade 12 students scoring higher on average (M=2.53, SD=0.53, t=-2.18, p=0.03). The overall conceptual test comparisons on both variables was carried out as additional supporting analysis of Chi-square test (Table 4), which denotes a meaningful information regarding the association of grade and gender difference towards the argumentation level distribution among The Philippines's high school students.

Table 3. Overall conceptual test comparisons on gender and level variables

Variables		General Biology			t	p
		N	Mean	SD		
Gender	Male	74	2.486	0.543	0.250	0.803
	Female	206	2.471	0.428		
Level	Grade 11	133	2.412	0.363	-2.182	0.030
	Grade 12	147	2.532	0.528		

Table 4 depicts that gender may not contribute to the distribution of argumentation level in each item. Conversely, our result indicates that grade difference might potentially associate with the distribution of argumentation level, indicated by the significant association found in five of six items of general biology test. In terms of grade differences, item 1 shows insignificance association ($\chi^2(4, 280)= .634, p=.959$) with the argumentation's level distribution.

Table 4. Summary of Chi-Square test

Argumentation Level in each Item	Gender			Level		
	Chi-square	df	*p-value*	Chi-square	df	*p-value*
Item 1	4.800	4	.308	.634	4	.959
Item 2	1.322	4	.858	19.169	4	.001*
Item 3	8.277	4	.082	20.601	4	.000*
Item 4	1.501	4	.827	13.641	4	.009*
Item 5	3.145	5	.678	15.337	5	.009*
Item 6	3.728	5	.589	34.483	5	.000*

Note: * indicates 0.05 level of significance

Discussion

In response to the first research question concerning variations in argumentation abilities based on different grade levels, our study findings reveal a significant association between students' grade level and proficiency in argumentation in most items. Notably, 12th-grade students more frequently exhibited a prevalence in argumentation ranging from level 4 to level 5. Within these levels, students can construct arguments comprising claims supported by reasoning and background information, accompanied by extended justification that fortifies their arguments. This result corresponds with the previous finding which denotes a developmental change between different levels (Crammond, 1998) and academic ability (Noviyanti et al., 2019). Additionally, the percentage of children using modals in argumentative writing gradually increased from less than 10% (ages 10 to 11 years) to approximately 40% (ages 15 to 16 years) (Golder & Coirier, 1994). According to a learning progression researcher, the complexity of students' argumentation will develop in tandem with the increasing of various argumentative functions in their discourse (Berland & McNeill, 2010). The characteristics of argumentation, when supported adequately over time, may exhibit greater complexity among higher grade students. Osborne et al. (2004) argued that the quality of argumentation relies on a foundation of relevant knowledge, serving as the basis for data and warrants in students' arguments.

According to result, the proficiency of argumentation ability has to consider grade differences which could be related to their higher comprehension in certain topic being tested. In the Philippines context, the high school students in STEM strand was observed to have significant correlation between their performance in science and their scientific reasoning

skills as well as their critical thinking skills (Farillon, 2022). Both of these skills were intrinsic to the development of scientific argumentation ability. Furthermore when it came to academic essay writing, it was noted that novice-writers tend to present ideas and information from sources without engaging in critique or evaluation of the sources they read, reflecting of what have been accepted and practiced in the particular population (Madrazo & Pulido, 2019). This indicates that the high cognitive functioning involved during writing argumentative text could be depend on experience and certain level of comprehension.

In terms of the second research question, our result indicates that significant associations were not found between gender and distributions of argumentation level. This finding confirms the prior study, which revealed that argumentation skills did not differ in gender (Bastarrica & Simmonds, 2019), and thus, it does not lead to gender bias (Hasnunidah & Wiono, 2019). In the Philippines, there is an emphasis on the lower likelihood of boys enrolling and persisting in formal education compared to girls, with boys consistently exhibiting lower academic performance than girls across all education levels (United States Agency for International Development, 2018). Accordingly, female group was found to provide more claim, evidence, rebuttals, and elaborated language styles/figurative when forming argumentation in related tasks (De Castro & Jalani, 2020). In the present study, the absence of significant association between gender and distribution of argumentation level could have been related to our approach in evaluating the argumentation ability. The present study demonstrated the arguments that are more closely associated with the context of science concept test rather than argumentation writing activities. Gender difference in argumentation observed in the literature often indicated a difference in communication style that more easily occurs in activities involving the writing of argumentative texts.

This study revealed potential approaches to aid students' abilities in constructing argumentation that can be observed through daily assessment. For instance, analysis based on the argumentation aspects may provide a richer, more detailed picture of students' proficiency in constructing argumentation in addition to students' conceptual understanding achievements. Although it also has some challenges since it may need deeper interpretation (Breivik, 2020). During the application, the utilization of effective teacher questioning has the potential to stimulate diverse modes of thinking among students and facilitate transitions from a mere factual recall to the application of higher-order thinking skills in the science classroom (MacKenzie, 2001; Martin & Hand, 2009). Additionally, it is more recommended to use dilemmatic questions to encourage students forming an argumentative statement. According to Widodo et al. (2019) dilemmatic cases in the lessons are potentially create a cognitive conflict that lead to changes in student's conceptions. This support common idea that questions in typical argumentation context need to go beyond a typical interaction between teacher and student in which teacher asks students with a question either with a known answers such as "What is the definition of biodiversity?" or a more open-ended ones such as "Which site exhibits the highest biodiversity?" (Berland & McNeill, 2010). Hence, for further investigation, we highly encourage future researchers to provide questions that can challenge students' ideas on particular topics of discussion.

The study, while providing insights about level and gender differences in argumentation ability among Philippines students, is not without its limitations, which warrant careful consideration and acknowledgment for its findings. The primary objective of the items in this study was to evaluate students' overall comprehension in a general biology test, and without an initial design for explicitly assessing argumentation. Accordingly, each item in general biology test might

exhibit distribution of argumentation's components differently. For instance, the item 2 and item 3 consist of questions with relatively known answered, in contrast to item 6, which poses a more dilemmatic and more open-ended question about virus. The limitations suggest caution attention when designing specific items for assessing argumentation in science learning. Nevertheless, the TAP employed as potential approach to gain reflection of argumentation skills by evaluating its components (e.g claim, warrants, and rebuttal). These components are able to be observed in the students' responses in the daily assessments.

Several important implications for teachers, as well as questions for future research, follow from this study. For instance, students' knowledge of argumentation model and content knowledge may affect their ability to argue. Students should be given practice about forming an argument with detail knowledge about argument's components. For example, educators must clearly outline the standard of "good" argument (Knudson, 1992). If students have not been exposed to the argumentative model or particular topic that were being discussed, they will have difficulty in deciding their position and thus, it makes it hard for them to support their position or claim with extended reasoning and justification. Additionally, it is also important to give appropriate probing instruction about argumentation. Students need to know when teachers want to assess their argumentation ability. This may give students transparency and clarity about the assessment and understand expectation for the assessment. Awareness of the clarity of the test may also motivate students to engage deeply with the material given.

Conclusions

The study was conducted to investigate the potentials of classroom formative assessment to aid argument formation in the Philippines biology classroom as an effort to foster argumentation practice during the science learning. In conclusion, our study has provided valuable insights into the argumentation skill profiles of Filipino senior high school students in the context of general biology concepts. The nuanced analysis of academic levels and gender-based disparities has laid the groundwork for targeted interventions and curriculum enhancements. Recognizing the dynamic nature of argumentation skills development and understanding the impact of gender on learning styles are crucial steps toward fostering a more inclusive and effective biology education system in the Philippines. This study not only contributes to the academic discourse but also offers practical implications for educators and policymakers striving to enhance science education at the secondary level.

Conflicts of Interest

The author(s) declared no conflicts of interest.

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