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Academic Performance of Grade 11 Biology on Modular Distance Learning: Basis for Instructional Material Development

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Abstract. Amidst the challenges posed by the Covid-19 pandemic in 2020, Filipino students persevered in their educational pursuits despite economic and physical constraints, adapting to distance learning modalities. This study aims to investigate the least mastered concepts in Grade 11 Biology among Filipino students during the implementation of modular distance learning amidst the educational disruption. A descriptive quantitative approach was employed, utilizing a researcher-made questionnaire validated by experts. The study involved 131 Grade 12 STEM students from a private senior high school. The collected data revealed that the least mastered topic was Energy Transformation, with additional concepts such as Cells, Biological Molecules, Organismal Biology, Genetics, Evolution, and Taxonomy remaining unmastered. These least mastered concepts in Biology hold a significant influence on students' academic performance. This implies that during the modular distance learning modality, learners were not able to master the desired Biological competencies of the senior high school curriculum. The research contributes to the understanding of how the transition to modular distance learning impacted the mastery of biology concepts, illuminating potential mismatches between the learning approach and the complexity of the subject matter. This study recommends possible instructional interventions that may include inquiry-based activities to further enhance the proficiency of students in biology and decrease students' difficulties.

Keywords: Scientific Explanation, Electrochemistry, Critical Action Research

INTRODUCTION

Biology is pivotal to one's education. To manage the difficulty of other Science disciplines in the higher education curriculum, it is imperative that they master this foundational subject during their high school years. The impact of biology education on society is substantial, as it plays a crucial role in determining the scientific literacy of individuals within a community with regard to concepts, principles, and ideas. Educating

today's learners poses a constant challenge for teachers, particularly in equipping students with fundamental competencies that will make them more globally competitive and scientifically literate, especially in the field of biology.

The challenge of educating modern learners is perpetual, with educators striving to equip students with fundamental competencies that foster global competitiveness and scientific literacy, particularly in the realm of biology. However, the current state of Biology proficiency among Filipino learners lags behind neighboring ASEAN countries (J.O. Afe, 2001). This deficiency translates into poor learning performance in Science, adversely affecting academic achievements and even the National Achievement Test (NAT) results. According to SEI-DOST (2011), Filipino students exhibit low analytical and communication skills, weak reasoning abilities, inadequate concept retention, and a lack of capacity to articulate thoughts. Despite interventions, the quality and quantity of science instruction pose threats to Philippine educational standards (P. J. P. Linog, R. G. Bongcawil, & R. B. Tumlos, 2013).

The Philippines' struggle to match academic standards is evident, especially in science subjects (M. A. A Millanes, E. E. S. Paderna, & E. N. Que, 2017; D. V. Jr Rogayan & L. F. Dollete, 2019). In the 2019 Program for International Student Assessment (PISA) results, the Philippines ranked 77th in Science among 78 participating countries. This trend is echoed in the National Achievement Test (NAT) and the World Economic Forum rankings (K. Schwab & X. Sala-i-Martín 2016). The lack of Biology proficiency is also reflected in the Trends in International Mathematics and Science Study (P. Foy, A. Arora, & G. M. Stanco 2013).

The students' low mastery of Science content, particularly Biology, presents a recurring challenge for science teachers, influenced by factors such as students' background knowledge, motivation, and cognitive capacity (J. Grosschedl, D. Mahler, T. Kleickmann, & U. Harms, 2014). Science's abstract nature, scientific language, and perceived lack of personal relevance contribute to the struggle (J. M. Fautch, 2015; P. H. Miller, J. Slawinski Blessing, & S. Schwartz, 2006; J. Osborne, and S. Collins, 2001).

The arrival of the COVID-19 pandemic in 2020 introduced a profound shift in education, compelling students to continue learning through distance modalities amidst economic and physical constraints. The pandemic not only resulted in a health crisis, but it has also resulted in an educational crisis. The school lockdown, an unprecedented event, has brought about significant changes to students' daily lives. As a result, they are spending less time on learning, experiencing increased stress, having different and potentially fewer interactions with peers and teachers, losing their learning motivation, resorting to more distance learning, and having less access to healthy nutrition (G. Di Pietro, F. Biagi, P. Dinis Mota Da Costa, Z. Karpinski, and J. Mazza, 2020). The sudden shift to new learning modalities and the indefinite suspension of classes have posed several challenges, especially for marginalized students who have unequal access to learning resources and limited direct instruction from teachers. This is yet another setback for the country, which was already struggling to improve the quality of basic education before the pandemic.

Given that Biology holds a significant place within the K to 12 science curriculum, understanding the concepts that learners struggle to master assumes paramount importance. Such insights not only illuminate the specific areas of challenge but also guide educators in crafting more effective pedagogical strategies. The current curriculum employs a spiral progression approach, imparting a diverse spectrum of competencies to learners in our knowledge-based society (A. L. Antipolo, & J. R. R. Rogayan, 2021). In school, students acquire and apply competencies through subject-area content and various learning experiences. These competencies empower students to harness and augment their existing knowledge, cognitive skills, and practical abilities. However, in reality, some science concepts can be challenging for students to master, leading to difficulties in achieving the required learning competencies.

The advent of the COVID-19 pandemic has further compounded this challenge, as the educational landscape shifted from traditional face-to-face instruction to modular learning approaches. This transition has not been without its consequences, particularly concerning

the comprehension and retention of complex subject matter. In response to these evolving circumstances, the Department of Education has taken a decisive step by streamlining the comprehensive K to 12 Curriculum Guides into a focused framework of Most Essential Learning Competencies (MELCs) (Department of Education, 2020) . This strategic adjustment emphasizes the core and indispensable competencies that learners must acquire, aligning education with the exigencies of the present times.

In this context, the study takes on a critical role. By delving into the academic performance and mastery levels of the students on their Grade 11 Biology amidst the COVID-19 educational disruption, this study aims to shed light on the least mastered concepts. This endeavor not only informs the researchers about the challenges students face but also equips them with insights into the educational strategies required to bolster their learning experiences. With the sudden shift to modular distance learning, this research gains further relevance as we seek to address the implications of this transition on academic achievement.

OBJECTIVES OF THE STUDY

Given that the majority of prior research addressing the least mastered competencies in Biology focused on junior high school students before the onset of the COVID-19 pandemic, this study aims to investigate the academic performance related to the least mastered concepts of senior high school students in Biology after the implementation of modular distance learning during the COVID-19 educational disruption. It is also the aim of this study to look for teaching strategies that would cater to the learning needs of Filipino students, especially in learning the least mastered concepts or topics in Biology.
Specifically, this study would like to achieve the following objectives:

1. Identify the least mastered concepts in Grade 11 Biology during the implementation of modular distance learning in order to assess the specific areas where students are facing challenges in their academic performance.
2. Recommend possible learning activities and instructional interventions to address and enhance the students learning on the least mastered competencies.

MATERIALS AND METHODS

This study utilized descriptive research employing a quantitative approach. This study employed a descriptive research design, utilizing a quantitative approach. Descriptive research is a method that focuses on observing and describing the characteristics and phenomena of a given population or situation. In this case, the research aims to provide a comprehensive overview of the academic performance and mastery levels of senior high school students in Biology. This quantitative approach involved the collection and analysis of numerical data to quantify patterns, relationships, and trends. By utilizing quantitative methods, this study gathered objective and measurable data regarding the students' academic performance in Grade 11 Biology. This data was then analyzed to identify the least mastered concepts and competencies among the students, shedding light on areas where improvement is needed.

An objective type questionnaire was employed as the primary data collection instrument. This method was chosen to assess and describe students' least mastered competencies in Biology. The questionnaire consisted of two parts: the first part gathered respondents' demographic information, including age, sex, and academic strand. The second part assessed students' least mastered concepts, focusing on topics such as Cell, Biological Molecules, Energy Transformation, Organismal Biology, Genetics, Evolution, and Taxonomy. The learning competencies were drawn from the K to 12 Most Essential Learning Competencies and K to 12 Senior High School STEM Specialized Subject – Biology (Department of Education, 2016; Department of Education, (DepEd) 2016; Department of Education, 2020). Each question in the second part required respondents to select the most appropriate answer from a set of predefined options.

The research questionnaire underwent a validation process to ensure construct and content validity. Three experts in research and science education from state universities in the Philippines assessed the questionnaire for item consistency. After validation, modifications were made based on the experts' feedback. A pilot testing phase involving 120 learners from another senior high school was conducted to evaluate the reliability of the questionnaire. Cronbach's Alpha was calculated using PSPP version 1.6.2-g78a33a, resulting in a coefficient of 0.835, indicating good internal consistency.

The study involved 131 Grade 12 STEM students from a private senior high school in Leyte, Philippines, regulated by the Department of Education. Purposive sampling was employed to select participants who had completed Grade 11 Biology during the implementation of modular distance learning.

The research was conducted during the first semester of 2022-2023. Data collection took place on January 4, 9, and 10, 2023, utilizing both online through Google forms and in-person answering of the questionnaire. The collected questionnaires were meticulously checked, tallied, tabulated, and analyzed. Statistical tools including frequency count, percent, and weighted mean were applied for performance assessment, overall mastery level determination, and competency-specific mastery assessment. PSPP version 1.6.2-g78a33a and MS Excel were utilized to process the collected data, ensuring accuracy and reliability in the analysis.

TABLE 1. *Mastery levels and percentage equivalent*

Mastery Level	Percentage Equivalent
Mastered	75-100
Low Mastery	51-74
Not Mastered	50 and below

Throughout the research process, ethical considerations were meticulously adhered to. The anonymity of respondents and their school was maintained throughout the study. Students' participation was voluntary, and their confidentiality was guaranteed. Additionally, informed consent was obtained from each participant, and their autonomy in decision-making was respected. To obtain the necessary information about the students' least mastered biology competencies and concepts, a formal communication requesting permission was submitted to the school's principal.

RESULTS AND DISCUSSION

The section presents and discuss the result of the study with reference to the objectives, which was to determine least learned concepts in Grade 11 Biology. The demographic profile of the students was obtained to provide a comprehensive background of their sex and age (Table 2).

TABLE 2. ***Profile of Grade 12 STEM students***

	Profile	Frequency	Percentage (%)
Sex	Male	48	36.6
	Female	83	63.4
Age	16	29	22.1
	17	66	50.4
	18	29	22.1
	Above 18	7	5.3

As shown in Table 2, the respondents of this study are mostly female (63.4%) compared to male which only constitutes 36.6% of the entire population. Out of 131 students, most of them are in the age of 17 (66 or 50.4%), followed by 16 (29 or 22.1%) and 18 (29 or 22.1%) and few aged of 18-above (7 or 5.3%).

TABLE 3. ***Students' Mastery on the Topic "Cell"***

Competencies	Frequency	Percentage (%)	Interpretation
1. Explain the significance or applications of mitosis/meiosis	74	56.5	LM
2. Explain the postulates of the cell theory	65	49.6	NM
3. Describe the structural components of the cell membrane.	60	45.4	NM
4. Describe the stages of mitosis/meiosis given 2n=6	49	37.4	NM
5. Characterize the phases of the cell cycle and their control points	68	51.9	LM
6. Compare mitosis and meiosis, and their role in the cell-division cycle	70	54.2	LM
7. Relate the structure and composition of the cell membrane to its function	47	35.9	NM
Overall	62	47.27	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Based on the data presented in Table 3, the highest frequencies were acquired in the following competencies: Explain the significance or applications of mitosis/meiosis (F=74, P=56.5), Characterize the phases of the cell cycle and their control points (F=68, P=51.9) and compare mitosis and meiosis, and their role in the cell-division cycle (F=70, P=54.2), however, based on the Dep Ed Mastery Levels and Percentage Equivalent, these three competencies are least mastered by the students.

As shown in Table 3, in the concept regarding the cell, the students obtained No Mastery on the following competencies: Explain the postulates of the Cell Theory (F=65, P=49.6), Describe the structural components of the cell membrane (F=60, P=45.4), Describe the stages of mitosis/meiosis given 2n=6 (F=49, P=37.4), and Relate the structure and composition of the cell membrane to its function (F=47, P=35.9). Based on the result, the overall mastery level of the students in the concept of cell is Not Mastered (M=62, P=47.27).

Certain topics in biology, particularly those related to complex areas such as cell division, photosynthesis, cell respiration, food chain-webs, and evolution, are known to be difficult to teach and learn (D.Y. Yip, 2001). Among these challenging topics, cell division consistently ranks at the top. These findings are consistent with previous studies that have reported poor understanding of cell division processes among students at all levels (S. Boujaoude, & W. Daher, 2018; J. Lewis, & C. Wood-Robinson, 2000). Additionally, only a few students at higher institutions possess prior knowledge of the subject matter beyond a basic understanding of the plasma membrane's structure and function as a semi-permeable barrier. Furthermore, many students struggle with accurately visualizing and comprehending molecular and cellular processes (P. McClean, C. Johnson, R. Rogers, L. Daniels, J. Reber, B. Slator, J. Terpstra, & A. White, 2005; C. Ragsdale, & E. Pedretti, 2004).

TABLE 4. ***Students' Mastery on the Topic "Biological Molecules"***

Competencies	Frequency	Percentage (%)	Interpretation
1. Explain the role of each biological molecule in specific metabolic processes	90	68.7	LM
2. Distinguish different transport mechanisms in cells (diffusion osmosis, facilitated transport, active transport).	65	49.6	NM
3. Describe the components of an enzyme.	47	35.9	NM
4.Identify the biological molecules (lipids, carbohydrates, proteins, and nucleic acids) according to their structure and function	51	38.55	NM
Overall	63	48.18	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Table 4 shows the students' least mastered competencies on the concept of biological molecules. The highest frequency was acquired in the competency, Explain the role of each biological molecule in specific metabolic processes (F=90, P=68.7) which is interpreted as Least Mastered competency.

The lowest frequencies were obtained in the following competencies: Distinguish different transport mechanisms in cells (diffusion osmosis, facilitated transport, active transport) (F= 65, P=49.6), Identify the biological molecules(lipids, carbohydrates, proteins, and nucleic acids) according to their structure and function (F=51, P=38.55), and Describe the components of an enzyme (F= 47, P= 35.9). The respondents had "no mastery" in the concept of biological molecules with the overall mean of 63 (P=48.18).

This coincides with the study of Cimer (2012) where biological molecules are considered challenging topic for secondary students (A. Çimer, (2012). The abstract nature of concepts is often linked to the challenges of teaching and comprehending molecular life science or biological molecules. The complexity of the material is the primary reason why students find it difficult to learn Biology. Every topic in Biology contains an abundance of information, making it overwhelming for students. This complexity is a result of the intricate systems that exist in all aspects of life, from molecules to the biosphere (F. Mazzocchi, 2008).

TABLE 5. ***Students' Mastery on the Topic "Energy Transformation"***

Competencies	Frequency	Percentage (%)	Interpretation
1. Distinguish major features of glycolysis, Krebs cycle, electron transport system, and chemiosmosis.	78	59.5	LM
2. Describe the importance of chlorophyll and other pigments.	67	51.1	LM
3. Describe the major features and chemical events in photosynthesis and respiration	108	82.4	M
4. Describe the major features and sequence the chemical events of cellular respiration.	46	35.1	NM
5. Differentiate basic features and importance of photosynthesis and respiration	84	64.1	LM
Overall	77	58.44	LM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

As shown above, the competency, "Describe the major features and chemical events in photosynthesis and respiration" is the mastered competency among the respondents with a frequency of 108 (P=82.4). The least mastered competencies are the following:

Differentiate basic features and importance of photosynthesis and respiration (F=84, P=64.1), Distinguish major features of glycolysis, Krebs cycle, electron transport system, and chemiosmosis (F=78, P=59.5), and Describe the importance of chlorophyll and other pigments (F=67, P= 51.1). The competency with No Mastery is "Describe the major features and sequence the chemical events of cellular respiration" (F= 46, P= 35.1). Overall, the students had "least mastery" in this concept with an overall mean of 77 (P=58.44).

Since cellular respiration occurs at the molecular level, students can't see or feel it. It is hard students to stay motivated and to study if they are not able to visualize the processes, and not see its relevance to the real world. Cellular respiration takes place through a multitude of complex steps where students have difficulty in understanding and remembering (A. Gilmore, 2022). Physiological processes such as respiration, and photosynthesis, water transport in plants, energy, oxygen transport, and gaseous exchange are multiple biological concepts that high school learners perceived as difficult topics to learn (A. Çimer, (2012).

TABLE 6. Students' Mastery on the Topic "Organismal Biology"

Competencies	Frequency	Percentage (%)	Interpretation
1. Classify different cell types (plant/animal tissues) and specify the function(s) of each	52	39.7	NM
2. Describe the different levels of biological organization from cell to biosphere	54	41.2	NM
3. Compare and contrast the following processes in plants and animals: reproduction, development, nutrition, gas exchange, transport/circulation, regulation of body fluids, chemical and nervous control, immune systems, and sensory and motor mechanisms	63	47.7	NM
4. Explain how some organisms maintain steady internal conditions that possess various structures and processes	37	28.2	NM
Overall	52	39.2	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Table 6 shows that students has no mastery in the competencies under the topic of organismal biology. As shown, respondents had "no mastery" in this concept with an overall mean of 52 (P= 39.2). As revealed by the students' answers, the competencies with no mastery are, Compare and contrast the following processes in plants and animals (F=63, P=47.7), Describe the different levels of biological organization from cell to biosphere (F=54, P=41.2), Classify different cell types (plant/animal tissues) and specify the function(s) of each (F=52, P=39.7). The lowest frequency was obtained in the competency, Explain how some organisms maintain steady internal conditions that possess various structures and processes (F=37, P=28.2).

The study of Organ Systems is not limited to one component of the human body, but also includes other related components, as well as the processes that occur within the system. These complex materials are the main reason why students find this topic challenging to study (R. M. Lieu, A. Gutierrez & J. F. Shaffer, 2018). This study's findings are consistent with the study of Alfiraida (2018), which concluded that the difficulty in comprehending topics such as Coordination, Immune System, and Homeostasis is due to their intricate characteristics (S. Alfiraida, 2018).

TABLE 7. ***Students' Mastery on the Topic "Genetics"***

Competencies	Frequency	Percentage (%)	Interpretation
1. Predict genotypes and phenotypes of parents and offspring using the laws of inheritance	69	52.7	LM
2. Explain the significance of meiosis in maintaining the chromosome number.	47	35.5	NM
3. Describe modifications to Mendel's classic ratios (gene interaction)	71	54.2	LM
4. Explain sex linkage and recombination	68	51.9	LM
5. Discuss crossing over and recombination in meiosis.	66	50.4	LM
Overall	64	48.94	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Based on the result presented in Table 7, there is no mastery among the students in the topic about Genetics. Higher frequencies were obtained in the following indicators: Describe modifications to Mendel's classic ratios (gene interaction) (F= 71, P= 54.2), Predict genotypes and phenotypes of parents and offspring using the laws of inheritance (F=69, P=52.7), Explain sex linkage and recombination (F= 68, P=51.9), Discuss crossing over and recombination in meiosis (F= 66, P= 50.4). However, these competencies are least mastered by the students. It can be deduced that the students are moving towards mastery in most concepts of Genetics however, the frequency values of the said competencies are still in the Low Mastery category. The lowest frequency obtained is on the competency Explain the significance of meiosis in maintaining the chromosome number (F=47, P=35.5) which is categorized as not mastered.

The result of this study supports the previous related literatures. Based on the study of Fauzi et.al in 2021, According to the perspective of students, Genetics is regarded as the most challenging topic (A. Fauzi, A. M. Rosyida, M. Rohma, & D. Khoiroh, 2021). This course is also considered the most difficult at the university level (A. Fauzi, & A. Fariantika, 2018). Studies conducted in various countries also revealed that Genetics is one of the most challenging topics in Senior High School ((A. Çimer, 2012; M. S. Topçu, & E. Şahin-Pekmez, 2009; C. Tekkaya, O. Ozkan, & S. Sungur, 2001). The research in Nigeria found that Genetics was not only perceived as a difficult topic, but also very difficult by the students (T. E. Agboghoroma, & E. O. Oyovwi, 2015). One of the reasons behind this difficulty is that many students are capable of memorizing Genetics concepts, but they struggle to comprehend the material being taught (M. S. Topçu, & E. Şahin-Pekmez, 2009).

TABLE 8. ***Students' Mastery on the Topic "Evolution"***

Competencies	Frequency	Percentage (%)	Interpretation
1. Explain the mechanisms that produce change in populations from generation to generation (e.g., artificial selection, natural selection, genetic drift, mutation, recombination).	58	44.3	NM
2. Explain evidences of evolution.	50	38.2	NM
3. Show patterns of descent with modification from common ancestors to produce the organismal diversity observed today	53	40.5	NM
Overall	54	41	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Based on Table 8, the students have no mastery of the concept of Evolution with an overall mean of 54 (P=41). All the competencies under the concept of Evolution obtained no mastery: Explain the mechanisms that produce change in populations from generation to generation (artificial selection, natural selection, genetic drift, mutation, recombination) (F=58, P=44.3), Show patterns of descent with modification from common ancestors to produce the organismal diversity observed today (F=53, P=40.5) and Explain evidences of evolution (F=50, P=38.2).

The result of this study is in-line with the different related literatures. Teaching and learning evolutionary theory in high school biology is crucial as it is considered to be the most complex theory in the field, emphasizing its significance. A considerable number of studies have shown that evolutionary theory is poorly understood by students J. E. Opfer, R. H. Nehm, & M. Ha, 2012). According to Bloom and Weisberg (2007), students' resistance to evolution instruction is mainly rooted in their prior knowledge before their exposure to science during childhood and elementary school (P. Bloom, & D. S. Weisberg, 2007). This resistance may be due to their belief that learning about evolution conflicts with their religious worldview. Moreover, the study conducted by Wong et al. (2021) found that students often struggle with understanding evolutionary concepts because they have difficulties with visualizing evolutionary processes and reasoning about evolutionary mechanisms (Wong, E. K., Halim, A. S., & Zimmerman, C, 2021).

TABLE 9. ***Students' Mastery on the Topic "Taxonomy"***

Competencies	Frequency	Percentage (%)	Interpretation
1.Identify the unique/distinctive characteristics of a specific taxon relative to other taxa	69	52.7	LM
2.Classify organisms using the hierarchical taxonomic system	58	44.3	NM
3.Explain how the structural and developmental characteristics and relatedness of DNA sequences are used in classifying living things	58	44.3	NM
Overall	62	47.27	NM

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

Table 9 reveals that the concept of Taxonomy is not fully mastered by Grade 12 students, as indicated by an overall frequency of 62 (47.27). The competency, "Identify the unique/distinctive characteristics of a specific taxon relative to other taxa (F=69, P=52.7)" is categorized as least mastered while all the other competencies under this concept obtained no mastery from the students. The competencies that are not mastered are the following: Classify organisms using the hierarchical taxonomic system (F=58, P=44.3) and Explain how the structural and developmental characteristics and relatedness of DNA sequences are used in classifying living things (F=58, P=44.3).

Taxonomy is involved in the classification and naming of organisms. It is the most basic because organisms cannot be discussed or treated in a scientific way until some classification has been achieved to recognize them and give them names. The findings of this study support previous research indicating that classification or taxonomy is a challenging topic for students (G. Hadiprayitno, Muhlis, & Kusmiyati, 2019). Other factors that contribute to difficulties in learning biology include teaching styles, the content of biological materials, and the academic environment. Many studies have shown that teachers tend to rely on traditional teaching methods, such as lectures and group work (Zhu, X., 2017; Balansag, K. G., 2022)). However, taxonomy has evolved rapidly with the advancement of science and technology, suggesting the need for a combination of traditional and innovative teaching methods (L. Maskour, A. Alami, M. Zaki, & B. Agorram, 2016; M. Ajmal Ali, G. Gyulai, N. Hidvégi, B. Kerti, F. M. Al Hemaid, A. K. Pandey, & J. Lee, 2014). Thus, in addition to the traditional teaching methods, such as

teacher presentations, lectures and traditional group work, fostering new and innovative learning pedagogies is needed.

TABLE 10. ***Summary of Least Mastered Topics in Biology***

Biology topics	Frequency	Percentage	Description	Rank
Cell	62	47.27	NM	3
Biological Molecules	63	48.18	NM	4
Energy Transformation	77	58.44	LM	6
Organismal Biology	52	39.2	NM	1
Genetics	64	48.94	NM	5
Evolution	54	41	NM	2
Taxonomy	62	47.27	NM	3

Legend: 0-50 = Not Mastered (NM), 51-74= Low Mastery (LM), 75-100= Mastered (M)

The summary of the mastery level of the Grade 12 STEM students on the biology concepts taken during their Grade 11 is presented in Table 10. The results show that the students' least mastered topic is the energy transformation (F=77, P=58.44). On the other hand, the topics with no mastery are the following: Genetics (F=64, P=48.94), Biological Molecules (F=63, P=48.18), Cell (F=62, P=47.27), Taxonomy (F=62, P=47.27), Evolution (F=54, P=41) and Organismal Biology (F=52, P=39.2).

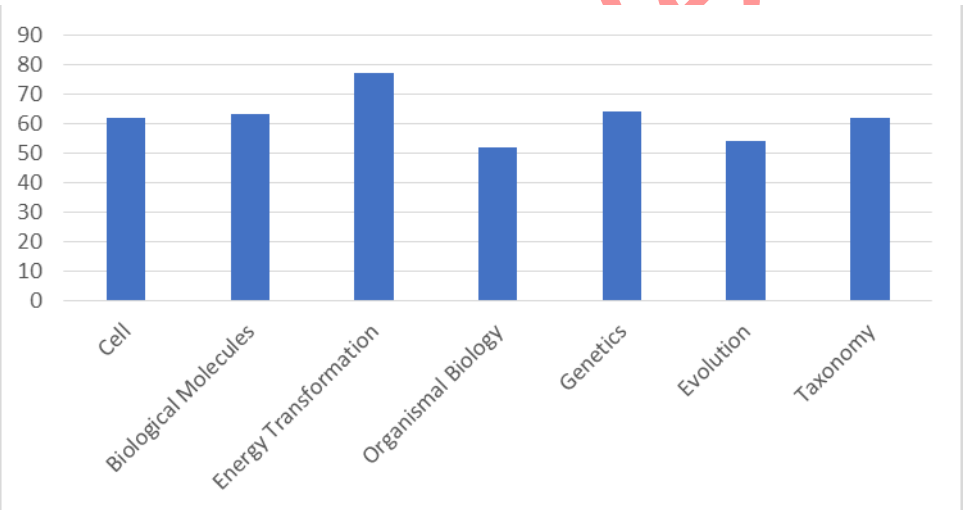

FIGURE 1. *Summary of the Students' Mastery level in Biology in Graphical Representation*

Learning biological knowledge and thematic thinking require an understanding of concepts, processes, phenomena and (hierarchical) structures, such as different levels of the cell, the genes or taxonomy. The higher the complexity of the concept, the more students find it difficult to understand. The abstract nature of Biology concepts is another factor that contributes to students' difficulties in learning Biology. A concept is considered abstract when students lack clear references to connect to their thoughts (M. Bolognesi, & P. Vernillo, 2019). Moreover, the abstract nature of concepts, combined with the difficulty of defining various Biology activities, is a natural characteristic of Biology materials that causes difficulty in learning the subject (A. Çimer, 2012).

Based on a study, students who struggle with learning Biology are more likely to lose interest in the subject (A. Fauzi, A. M. Rosyida, M. Rohma, & D. Khoiroh, 2021). This suggests that students' perceptions of the difficulty of Biology are a major hindrance to their interest in the subject. Students' interest level is a key factor in their learning success. When students find a subject difficult to learn, their motivation and efficacy decrease. This is supported by a report from England, which found that students' interest and motivation in learning science are influenced by both teachers' practices and students' perceptions of

the subject (S. Shirazi, 2017). Similarly, a study in Myanmar revealed a significant correlation between the level of difficulty and students' interest and motivation in learning Biology (H. Y. Soe, 2018). Additionally, research conducted in Brazil and Portugal showed that students' interest and motivation significantly decreased when they struggled to understand Biology concepts (J. R. S. da Silva, F. Guimarães, & P. T. Sano, 2016).

The unprecedented disruption brought about by the COVID-19 pandemic further compounded these academic challenges. Shifting abruptly to online and modular learning methods led to decrease in motivation and deteriorating academic performance among students. The lack of infrastructure and social support in modular learning hindered their educational progress (C. Tan, 2020). The COVID-19 pandemic has taken educators and students by surprise, leading to various challenges in the learning process. Respondents in a related study expressed their preference against online learning methods during the pandemic due to factors like unreliable internet connectivity and difficulty in comprehending subject matter without direct teacher guidance (E. Chung, G. Subramaniam, & L. Christ Dass, 2020).

Furthermore, aside from the previously mentioned factors, the abstract nature of Biology concepts is also a contributing factor to students' difficulty in comprehending the subject (A. Fauzi, A. M. Rosyida, M. Rohma, & D. Khoiroh, 2021). A concept is considered abstract if students cannot form clear references in their minds (S. Shirazi, 2017). In line with this, the abstract nature of Biology concepts and the difficulty in defining various Biology activities are natural characteristics of the subject and are identified as the primary causes of difficulty in learning Biology (A. Çimer, 2012).

These least mastered concepts in Biology hold a significant influence on students' academic performance. When students encounter difficulties in mastering these concepts, their ability to grasp foundational principles and interrelated topics is compromised. As a consequence, their overall understanding of Biology is hindered, leading to potential gaps in their knowledge framework. These knowledge gaps can manifest in various ways. Initially, they hinder students from fully grasping subsequent topics that rely on foundational concepts, potentially creating a domino effect where challenges in one area lead to difficulties in comprehending advanced materials. Additionally, the least mastered concepts act as cornerstones for broader themes in Biology. For instance, a weak grasp of cellular biology may undermine students' comprehension of genetics, evolution, and organismal biology, which rely on a solid understanding of cellular processes. Such interdependencies magnify the impact of least mastered concepts on academic performance.

Building upon these insights, proposed instructional intervention activities emerged, designed to address the identified gaps. This intervention encompasses the least mastered concepts, offering suggested pedagogical strategies, learning tasks, and assessment measures. In this regard, Table 11 encapsulates a comprehensive summary of the instructional intervention plan tailored to topics exhibiting low mastery.

Several studies support the model-making activities in teaching Biology concepts. The studies of Li, Li, Liu, and Dong (2019) and Chandler and Quinlan (2016) suggest that model-making activities, such as body mapping, can be an effective way to improve students' understanding of biology concepts, particularly when it comes to complex and abstract ideas (X. Li, Y. Li, X. Liu, & H. Dong, 2019). Chandler & Quinlan (2016) found that the body mapping activity improved students' understanding of the interrelationships between different organ systems, as well as their ability to integrate different types of information (such as structure and function) to understand complex biological concepts (P. Chandler, & P. T. Quinlan, 2016). These activities can also help improve students' attitudes and interest in the subject, which can lead to improved learning outcomes.

TABLE 11. ***Proposed instructional intervention in the not mastered and least mastered topics in Biology***

Not Mastered Topic	Pedagogical Strategies	Learning Task	Assessment Task
1. Organismal Biology	DIY Body Chart Model	The students will create a flip chart with all the organ systems and processes included. After creating the model, the students will discuss the different concepts using it.	Use of rubrics as an assessment tool
2. Evolution	Mind-mapping	The students will create a mind map regarding the different concepts in Evolution and connect those concepts with each other. This technique encourages the learner to think and explore concepts using visual-spatial relationships flowing from a central theme to peripheral branches which can be inter-related.	Use of rubrics as assessment tool
3. Cell	Visual Simulation	To observe and understand the processes occurring inside the cell, as well as the various organelles involved, learners will use technology or computers to view realistic graphical representations.	Mix-Match-and-Paste Quiz
4. Taxonomy	Campus Walk (Place-based Learning)	Going around the school ground while looking on the organism found inside the school premise and classify them scientifically.	Moving exam
5. Biological Molecules	Lights, Camera, Acting Transport	The activity involves three acts or scenarios in which students, representing various molecules, ions and components of the plasma membrane, interact to learn the fundamentals of passive transport, primary active transport and co-transport across cellular membranes.	Use of rubrics as assessment tool.
6. Genetics	Guided Discovery Problems Visual Simulation	Debugging the different parts of the process. Observing the different processes that happens during crossing over and recombination.	Problem solving Short narrative report
7. Energy Transformation	Visual Simulation Laboratory Exercises	Observing the different processes that happens during cellular respiration and photosynthesis. Conducting hand-on exercises/experiments that demonstrate cellular respiration and photosynthesis.	Short narrative report Scientific laboratory report

The use of mind-mapping as a pedagogical tool for teaching Evolution, particularly in terms of helping students organize and integrate complex information and develop metacognitive skills is supported by research studies. Chan and Mohd Sofi (2018) used concept mapping as a teaching tool to help students better understand the principles of evolution. The study found that using concept mapping helped students develop a deeper understanding of evolution concepts and improved their ability to identify and articulate relationships between different evolutionary concepts (Z. C. Chan, & N. Mohd Sofi , 2018).

Interactive multimedia learning materials including visual simulations are effective tool in learning the different cell structures and process (Z. Kaya & M. Aydemir, 2021). D'Agostino, Chiu, and Cho (2016), found that virtual labs improved engagement, understanding of course content, critical thinking, and problem-solving skills in a biology course since it provides realistic experience. Moreover, Loertscher et al. (2020) concluded that virtual laboratory was an effective tool for improving student understanding and engagement in cell biology, and that the visual simulations were particularly helpful in enhancing student learning .

Place-based learning is an educational approach that emphasizes using the local environment as a context for learning. Research studies (K. Jorgensen & A.W. Gotwals, 2020; C. Eames, & T. Slater, 2016) have shown that place-based learning can improve student engagement, motivation, and learning outcomes by making learning more relevant, meaningful, and connected to students' lives and communities.

The Lights, Camera, Acting Transport pedagogical approach is a creative and engaging way to teach students about the fundamentals of transport across cellular membranes. Kloser et al.,(2016) and Engle et al.,(2016) has shown that this type of active and hands-on approach to learning is effective in promoting student engagement, motivation, and conceptual understanding of complex scientific concepts such as biological molecules and transport across cellular membranes (M. J. Kloser, S. E. Brownell, N. R. Chiariello, & T. Fukami, 2016; J. A. Engle, E. K. Berkes, & J. D. Warren, 2016)

According to Wolfe & Alexander (2008), guided discovery problems are a pedagogical approach to teaching that involves presenting students with a problem or challenge and then providing guidance and support as they work to solve it (C. R. Wolfe & P.A. Alexander, 2008). Several studies have positive results using guided discovery approach in teaching. The study of Kavak, Ozdilek, Kavak (2015) published in the Journal of Biology Education found that students who participated in guided discovery problems performed better on a post-test of genetics knowledge than those who received traditional lecture-based instruction. Another study found that the debugging task was effective for improving student understanding of the genetic process and for promoting student engagement in the learning process (D. Arthur, J. Settlage Jr, & T. A. Rutherford, 2014). Multiple studies support the effectivity of laboratory exercises and laboratory-based instructions in improving student knowledge and understanding of these biological processes (N. Nwosu, O. T. Obiakor, & C. S. Ezeonu, 2020; S. Sevilmez, & S. Erden, 2017; R. O'Brien & M. Moeller, 2019; E. J. Yezierski & B.D. Brumfield, 2012).

The instructional intervention proposed in this study consists of pedagogical strategies aimed at improving the understanding of the least mastered concepts in Biology among Grade 12 STEM students. These strategies are crucial in addressing the difficulties students face in learning Biology, particularly in light of the sudden shift to remote learning due to the COVID-19 pandemic. With the decreasing number of cases of COVID-19 in the Philippines, the intervention can now be implemented in-person, providing students with the opportunity to benefit from the realistic graphical representations of cellular processes and organelles, which can be viewed using technology or a computer. The effectiveness of this intervention may help improve the current state of biology education and address the challenges brought about by the changes in the teaching-learning process during the global health crisis.

CONCLUSIONS AND RECOMMENDATIONS

Based on the comprehensive investigation conducted, this study has successfully identified the areas of least mastered concepts in Grade 11 Biology, a critical exploration undertaken within the context of Modular Distance Learning. The findings notably pinpoint Energy Transformation as the least mastered topic, accompanied by the notable inclusion of other topics, namely Cells, Biological Molecules, Organismal Biology, Genetics, Evolution, and Taxonomy, which remained unmastered by the student cohort.

These revelations collectively illuminate a significant trend—students grappled with diverse biological concepts throughout the modular distance learning paradigm. The implications of these outcomes extend beyond mere observation; they suggest a potential misalignment between the mode of instruction and the receptivity of students. Evidently, the modular approach might have posed challenges in rendering these topics engaging and accessible to the learners. Furthermore, the complexities embedded within these concepts could have surpassed the students' current level of comprehension, especially given the absence of direct teacher guidance. The convergence of these factors underscores the need for carefully tailored instructional strategies that account for both the unique learning environment and the inherent complexities of the biological subject matter.

Based on this study's result, it is recommended by the researcher to have instructional interventions on these topics to remediate the escalation of this problem. The Science teachers may implement the proposed instructional intervention to minimize the difficulty of learning the said topics. Although the findings revealed the learners' least-mastered and not mastered topics, there are some limitations that could serve as an opportunity for future research. First, the study's findings are limited to the population under study which are private senior high school students. This may not accurately represent or speak for the performance of other Senior High Schools and their lack of biology competency because performance and mastery can be affected by several factors both inside and outside of school, such as student characteristics, teacher effectiveness, learning strategies employed and students' motivation. With these, it may be worthwhile to broaden the scope of the study to include other senior high schools, both public and private, to validate the consistency of the results. Second, the tool that included multiple-choice questions may not have captured the students' learning since each competency is represented with one item only. Finally, incorporating qualitative methods such as interviews and focal group discussions may provide a better and richer understanding of the underlying reasons why students struggle with a specific biology learning competency which affected their overall academic performance in the subject.

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