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Research Article

Least mastered competencies in biology: Basis for instructional intervention

Jack Torno Delos Santos [a,1], Roselyn R. Lim [a,2], Danilo V. Rogayan Jr. [a,3*]

[a] College of Teacher Education, President Ramon Magsaysay State University, Zambales 2207, Philippines

[1] jacktornodelossantos@gmail.com; [2] limroselyn15@gmail.com; [3] danrogayan@gmail.com*

* Corresponding author

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ABSTRACT

Teaching the students of today's generation has been a perennial challenge for the teachers, particularly in providing these students the core competencies to be more globally competitive and functionality literate in science and in biological disciplines in particular. The purpose of this study was to determine the least mastered competencies of 10 graders in different biology competencies they learned from grade 7 to grade 10. The researchers used a quantitative descriptive cross-sectional study utilizing a self-made survey questionnaire. The respondents were 122 of 10 graders of three state-owned secondary schools in Zambales, Philippines. The findings showed that the biology competencies for seven and eight graders were the least mastered by graders. There were also significant differences of students' least mastered competencies by school and sex. There were also significant correlations among the least mastered competencies in biology. The study recommends that science teachers may consider employing inquiry-based and hands-on learning activities to further enhance the proficiency of students in biology and decrease students' difficulties.

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INTRODUCTION

Biology education contributes a significant impact in the society because this will define the literacy of every individual in a particular community in terms of scientific concepts, ideas, and principles. Educating every learner to higher standards of performance has been a perennial challenge for the teachers, specifically in providing the students the needed competencies to become more globally competitive and functionality literate, especially in biological disciplines.

Globally, the Philippines lags behind other countries in the quality of education, particularly in a science subject (Millanes et al., 2017; Rogayan Jr & Dollete, 2019). The Philippines ranked 70th out of 144 participating countries in terms of the quality of mathematics and science education, according to the World Economic Forum by Schwab and Sala-i-Martín (2016). This was likewise reflected in the Trends in International Mathematics and Science Study (Foy et al., 2013). In comparing the Grade 8 students' performances in mathematics and science, the Philippines ranked 34th out of 38 countries and 43rd out of 46 countries, respectively.

One common problem faced by science students is their low mastery in content knowledge in science, most specifically in biology. This is supported by the study of Großschedl et al. (2014) which stated that the most challenging part for educators is to assist learners to development their knowledge in subject matter such as in biology. They cited that these difficulties are affected by different factors such as students' background knowledge, intelligence, and motivation.

According to Buckley (2018) the main view of studying Biology is to know about humans and nature. That is why Biology is taught in every school to learn the essence of life and, in addition, to connect the common learnings and new learnings and suggest methods to incorporate it in the formal learning system of formal education (Ardan et al., 2015). Study indicates that out of all science topics, learners enjoy and have a high interest in Biology (Awan et al., 2011; Baram & Yarden, 2005; Osborne & Collins, 2000; Prokop et al., 2007). However, despite the popularity of Biology among students, conceptual understanding and performance are still low (Çimer, 2004).

In the study of Etobro and Fabinu (2017), they reported that students usually have difficulties in nature nutrient cycle, environmental management, conservation of natural resources, and pests and diseases of crops in the reproduction of plants. Çimer (2004) argued that many Biology concepts can be seen as challenging to pick up by high school students. Tekkaya et al (2001) found hard ideas considering the secondary students' Mendelian genetics, nervous system, hormones, chromosomes, mitosis, genes, and meiosis. This is parallel with the findings of Bahar et al (1999) that the transportation of water in plants and genetics were the two science aspects that proved to be most troublesome. Moreover, during the current pandemic, learning activities face the biggest challenge with an online learning system. Furthermore Özcan (2003) which stressed that suffering difficulties in different topics in biology will result to negative effects on learners' achievement and motivation.

According to SEI-DOST (2011) reported that learners from the Philippines have poor communication skills and analytical abilities, low reasoning, poor retention of concepts, and cannot explain and express ideas in their own words. Similarly, a local study by Lawsin and Garcia (2017) revealed that Mendelian and non-Mendelian genetics, mitosis and meiosis, and endocrine system are the top three topics where the students have low conceptual understanding and least mastered competencies as indicated by biology in-service teachers of National Capital Region.

Since biology is one of the components of science subject in the K to 12 curriculums, understanding the difficulties of the learners in this area will provide insights and directions to teachers to better design pedagogical plans. The current curriculum, which uses spiral progression approach, provided a range of competencies to the learners in a knowledge-based society (Antipolo & Danilo, 2021). So far, there are only a few studies that discuss the mapping of low mastery competencies in the field of Biology, especially in junior high schools. Hence, the present study identified the students with least mastered competencies in Biology embedded across the junior high school in different levels along with the topics in animals and plants parts and functions of; genetics, biodiversity and evolution; and ecosystems, inheritance and variation. The study likewise investigated the different reasons which affect the learners from achieving the standard competencies and classified the different areas in Biology where the students mostly experience difficulties. In the future, this research can be used as a reference source for similar research on least mastery competencies in the field of Biology.

METHOD

The study used descriptive-survey research employing both quantitative and qualitative approaches. The survey questionnaire was used as the main instrument in gathering the required data. These methods were used in order to describe the least mastered competencies of the students in Biology. Quantitative research explains phenomena by collecting numerical data analyzed using mathematically based methods, particularly statistics (Aliaga & Gunderson, 2000).

The respondents of this study were the 122 Grade 10 students of three state-owned secondary schools in Zambales from School A with 17 respondents, School B with 66 and School C with 39 respondents. All the schools are regulated by the Philippine Department of Education. The respondents were chosen since they have enrolled all the biology subjects in the junior high school curriculum. The respondents were chosen through cluster sampling. The clusters considered by the researchers are the national secondary schools found in Southern Zambales.

The Biology Competencies survey questionnaire (BCSQ) served as the main instrument in collecting the data. It is made up of two parts. The first part consists of the demographic profile of the respondents. The profile of the respondents includes the school, age and sex. The second part assessed the students' least mastered competencies in Biology in Grade 7 (13 items), Grade 8 (12 items), Grade 9 (6 items), and Grade 10 (11 items). These competencies included Parts and Function of Animals and Plants; Heredity: Inheritance and Variation; Biodiversity; Evolution; and Ecosystem. The survey tool is a researcher-made questionnaire. The learning competencies were lifted from the K to 12 Science Curriculum Guide (Department of Education Phillipines, 2016). The tool was subjected to construct and content validity. Three experts were tapped to check the consistency of the items in each variable. A total number of 30 learners who were not part of the research were asked to answer the survey questionnaire for pilot testing. The responses were processed and subjected to reliability test.

The computation of the reliability test using Cronbach Alpha was made through SPSS version 25.0. It was found out that the instrument has an excellent internal consistency having obtained a Cronbach's Alpha coefficient of 0.965. Table 1 shows the reliability coefficient of the instrument using Cronbach's alpha.

Table 1. Reliability Coefficient of the Instrument Using Cronbach's Alpha

Variable	No. of Items	Cronbach's Alpha	Interpretation
Grade 7	13	0.876	Good
Grade 8	12	0.866	Good
Grade 9	6	0.850	Good
Grade 10	11	0.952	Excellent
Overall	42	0.965	Excellent

The research was conducted before the pandemic and was completed in June 2020. The first phase was the development of the research questionnaire. This was done by the researchers and validated by research experts in one state university in the Philippines. After validation, the researchers revised some questions in the research questionnaire checked by the research experts before seeking permission to the principal of a public secondary school to conduct pilot testing. A total of 30 non-respondents were selected for the pilot testing of the research tool. After the pilot testing, the researchers gauged the questionnaire's reliability using Cronbach's Alpha. After the content validity and reliability testing, the researchers administered the survey questionnaires.

The computer software SPSS version 25 and MS Excel 2016 were used for the processing of data. Statistical tools used were fequency count, percent, weighted mean, analysis of variance (ANOVA) and Pearson-r correlation. To maintain ethics in conducting this research, the researchers strictly observed the following: The respondents' names were not mentioned in any portion of this research. The students were not physically and emotionally forced or harmed just to be a respondent of the study. The researchers protected and respected any other concerns and decision of the respondents and were not be put in any part of this study. A communication letter was presented to the school principals to ask permission to gather the needed data regarding students' least mastered competencies in biology. The responses of the students were treated with utmost confidentiality. An informed consent form was explained and signed by the respondents.

RESULTS AND DISCUSSION

The profile of the students was determined to provide a comprehensive background of their age, sex and school (Table 2).

Table 2. Profile of the Grade 10 students

Profile		Frequency	Percentage (%)
School	School A	17	13.90
	School B	66	54.10
	School C	39	32.00
	Total	122	100.0
Age	18- above	7	5.7
	16-17	77	63.10
	15-below	38	31.10
	Total	122	100.0
Sex	Male	56	45.90
	Female	66	54.10
	Total	122	100.0

As shown in the table 2 more than half of the respondents came from School B (66, 54.10%), followed by School C (39, 32.00%) and School A (17, 13.90%). Out of 122 student-respondents most of them are in the aged of 16-17 (77 or 63.10%), and few aged of 18-above 7 or 5.7%. Females (66 or 54.10%) are high in number of respondents than males (56 or 45.90%). The result shows that there are more female students in the distribution. Chi et al (2017) mentioned that the analysis of ROSE (Relevance of Science Education) data indicates a difference in science-related affective variables based on gender. Boys' and girls' interests are different in context dependency and also in level of development, girls are more concerns than boys when it comes to environment but boys are more aggressive than girls to become scientists and get a job in Sjøberg & Schreiner (2010). As shown in Table 3, the respondents obtained "low mastery" in Grade 7 biology competencies with an overall mean of 2.44 (SD=0.49).

Table 3. Students' least mastered competencies in Grade 7 biology

Indicators	M	SD	Description
1. Identify parts of the microscope and their functions.	2.40	0.79	LM
2. Focus specimens using the compound microscope.	2.08	0.84	LM
3. Describe the different levels of biological organization from cell to biosphere.	2.39	0.77	LM
4. Differentiate plant and animal cells according to presence or absence of certain organelles.	2.75	0.77	MTM
5. Explain why the cell is considered the basic structural and functional unit of all organisms.	2.08	0.81	LM
6. Identify beneficial and harmful microorganisms.	2.43	0.91	LM
7. Differentiate asexual from sexual reproduction in terms of number of individuals involved.	2.73	0.90	MTM
8. Differentiate asexual from sexual reproduction in terms of similarities of offspring to parents.	2.66	0.87	MTM
9. Describe the process of fertilization.	2.79	0.90	MTM
10. Differentiate biotic from abiotic components of an ecosystem.	2.25	0.85	LM
11. Describe the different ecological relationships found in an ecosystem.	2.40	0.95	LM
12. Predict the effect of changes in one population on other populations in the ecosystem.	2.40	0.82	LM
13. Predict the effect of changes in abiotic factors on the ecosystem.	2.17	0.88	LM
Overall	2.44	0.49	LM

Legend: M- Mastered (3.50-4.00), MTM- Moving Towards Mastery (2.50-3.49), LM- Low Mastery (1.50-2.49), NM- No Mastery (1.00-1.49)

The highest means were acquired in the following indicators: Describe the process of fertilization (M=2.79, SD=0.90), differentiate plant and animal cells according to presence or absence of certain organelles (M=2.75, SD=0.77), differentiate asexual from sexual reproduction in terms of number of individuals involved (M=2.73, SD=0.90).

The lowest means were obtained in the following indicators: Focus specimens using the compound microscope (M= 2.08, SD= 0.84), explain why the cell is considered the basic structural and functional unit of all organisms (M= 2.08, SD=0.81), predict the effect of changes in abiotic factors on the ecosystem (M= 2.17, SD= 0.88), differentiate biotic from abiotic components of an ecosystem (M=2.25, SD=0.85), describe the different levels of biological organization from cell to biosphere. (M= 2.39, SD= 0.77).

Based on the open-ended question, the low mastery of the students among the grade 7 biology competencies are on identifying the parts of microscope (f=17) and focusing specimen using the compound microscope (f=9). The reasons of the students' low mastery include the prohibition of the use of microscope by the teacher, lack of interest, poor retention ability, poor conceptual understanding, and lack of knowledge on handling laboratory apparatuses.

According to the study of Čipková et al. (2018) students' interest and their benefit for everyday life are also necessary to consider in the selected curriculum. Teachers' teaching style, nature of the topic, attitude towards the topic, students' learning and studying habits, and lack of resources are the main causes of learning difficulties. If learners were not happy with the methods of how biology is taught, they may show negative attitudes and disinterest towards biology (Çimer, 2012). Table 4 shows the students' least mastered competencies in Grade 8 Biology.

The respondents had "moving towards mastery" in Grade 8 biology competencies with the overall mean of 2.67 (SD=0.60). The highest means were acquired in the following indicators: Identify healthful practices that affect the digestive system (M= 2.63, SD= 0.84), explain how diseases of the digestive system are prevented, detected, and treated (M=2.63, SD= 0.85), explain the advantage of high biodiversity in maintaining the stability of an ecosystem (M=2.43, SD= 0.79), analyze the roles of organisms in the cycling of materials (M=2.39, SD= 0.85).

The lowest means were obtained in the following indicators: Classify organisms using the hierarchical taxonomic system (M= 1.99, SD= 0.85), explain the significance of meiosis in maintaining the chromosome number (M=2.10, SD=0.81), explain ingestion, absorption, assimilation, and excretion (M=2.11, SD=0.82), predict phenotypic expressions of traits following simple patterns of inheritance (M= 2.23, SD= 0.84).

As indicated in the students' responses in the open-ended question in the grade 8 biology competencies, it is shown that the lowest mastery they have encountered are comparing mitosis and meiosis, and their role in the cell division cycle (f=11), describing the transfer of energy through the trophic levels (f=11) and classifying organisms using the hierarchical taxonomic system (f=10). The reasons for the students' low mastery include the lack of interest, not discussed thoroughly, poor conceptual understanding, poor retention, having poor prior knowledge about the topic, and dislike science lessons.

Table 4. Students' least mastered competencies in Grade 8 biology

Indicators	M	SD	Description
1. Explain ingestion, absorption, assimilation, and excretion.	2.11	0.82	LM
2. Explain how diseases of the digestive system are prevented, detected, and treated.	2.63	0.85	MTM
3. Identify healthful practices that affect the digestive system.	2.63	0.84	MTM
4. Compare mitosis and meiosis, and their role in the cell-division cycle.	2.29	0.88	LM
5. Explain the significance of meiosis in maintaining the chromosome number.	2.10	0.81	LM
6. Predict phenotypic expressions of traits following simple patterns of inheritance.	2.23	0.84	LM
7. Explain the concept of a species.	2.32	0.92	LM
8. Classify organisms using the hierarchical taxonomic system.	1.99	0.85	LM
9. Explain the advantage of high biodiversity in maintaining the stability of an ecosystem.	2.43	0.79	LM
10. Describe the transfer of energy through the trophic levels.	2.26	0.80	LM
11. Analyze the roles of organisms in the cycling of materials.	2.39	0.85	LM
12. Explain how materials cycle in an ecosystem.	2.36	0.89	LM
Overall	2.67	0.60	MTM

Legend: M- Mastered (3.50-4.00), MTM- Moving Towards Mastery (2.50-3.49), LM- Low Mastery (1.50-2.49), NM- No Mastery (1.00-1.49)

As cited in the study of Çimer (2012) and Tekkaya et al (2001), that secondary students' found that mitosis and meiosis, hormones, genes, and chromosomes, mendelian genetics, nervous system are also found and were considered difficult concept to study. Making biology teaching and leZarning effective may facilitate the implementation of the new curriculum and help policy-makers and teachers to update in the line with the learners, knowing their views of the affecting their learning needs. Moreover, teachers can see the learners strong and weak areas regarding in learning biology (Çimer, 2012). As shown in the Table 5, the Grade 10 students obtained "low mastery" in Grade 9 competencies with an overall mean of 2.31 (SD=0.54).

Table 5. Students' least mastered competencies in Grade 9 biology

Indicators	M	SD	Description
1. Explain how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body.	3.05	0.81	MTM
2. Infer how one's lifestyle can affect the functioning of respiratory and circulatory systems.	2.84	0.83	MTM
3. Describe the location of genes in chromosomes.	2.65	0.89	MTM
4. Explain the different patterns of non-Mendelian inheritance.	2.20	0.88	LM
5. Relate species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment.	2.60	0.81	MTM
6. Differentiate basic features and importance of photosynthesis and respiration.	2.64	0.87	MTM
Overall	2.31	0.54	LM

Legend: M- Mastered (3.50-4.00), MTM- Moving Towards Mastery (2.50-3.49), LM- Low Mastery (1.50-2.49), NM- No Mastery (1.00-1.49)

The highest means were acquired in the following indicators: Explain how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body (M= 3.05, SD= 0.81), infer how one's lifestyle can affect the functioning of respiratory and circulatory systems (M=2.84, SD= 0.83), describe the location of genes in chromosomes (M=2.65, SD= 0.89).

The lowest means obtained in the following indicators: Explain the different patterns of non-Mendelian inheritance (M=2.20, SD=0.88), relate species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment (M= 2.60, SD= 0.81), differentiate basic features and importance of photosynthesis and respiration (M= 2.64, SD= 0.87).

As revealed by the student responses, in the open-ended question, the lowest mastery they have in grade 9 biology is explaining the different patterns of non-mendelian inheritance (f=18) and describing the location of genes in chromosomes (f=10). The students' reasons for low mastery include the lack of interest in the topics, poor retention, poor conceptual understanding, and poor prior knowledge about the topic and not thoroughly discussed by the teacher.

According to Bahar et al., (1999), the chief biology examiners of Scottish Examination Board in their annual report (1992-1995) supported the opinion of the students that the general area of genetics is still posing problems. Protein synthesis, respiration, and photosynthesis, water transport in plants, physiological processes, energy, oxygen transport, gaseous exchange, mendelian genetics, organs, hormonal regulation, mitosis and meiosis, central nervous system, cells, and genetic engineering are multiple concepts in biology that high school learners can be perceived as difficult topics to learn (Çimer, 2012). Table 6 shows the students' least mastered competencies in grade 10 Biology. As shown, respondents had "moving towards mastery" in Grade 10 competencies with the overall means of 2.96 (SD= 0.66).

Table 6. Students' least mastered competencies in grade 10 biology

Indicators	M	SD	Description
1. Describe the parts of the reproductive system and their functions.	3.43	0.71	MTM
2. Explain the role of hormones involved in the female and male reproductive systems.	3.33	0.75	MTM
3. Describe the feedback mechanisms involved in regulating processes in the female reproductive system (e.g., menstrual cycle).	3.16	0.86	MTM
4. Describe how the nervous system coordinates and regulates these feedback mechanisms to maintain homeostasis.	2.93	0.83	MTM
5. Explain how protein is made using information from DNA.	2.98	0.89	MTM
6. Explain how mutations may cause changes in the structure and function of a protein.	2.83	0.90	MTM
7. Explain how fossil records, comparative anatomy, and genetic information provide evidence for evolution.	2.82	0.85	MTM
8. Explain the occurrence of evolution.	2.73	0.93	MTM
9. Explain how species diversity increases the probability of adaptation and survival of organisms in changing environments.	2.75	0.90	MTM
10. Explain the relationship between population growth and carrying capacity.	2.81	0.88	MTM
11. Suggest ways to minimize human impact on the environment.	2.83	0.92	MTM
Overall	2.96	0.66	MTM

Legend: M- Mastered (3.50-4.00), MTM- Moving Towards Mastery (2.50-3.49), LM- Low Mastery (1.50-2.49), NM- No Mastery (1.00-1.49)

Higher means were obtained in the following indicators: Describe the parts of the reproductive system and their functions (M= 3.43, SD= 0.71), Explain the role of hormones involved in the female and male reproductive systems (M= 3.33, SD=0.75), Describe the feedback mechanisms involved in regulating processes in the female reproductive system (e.g., menstrual cycle) (M= 3.16, SD= 0.86), Explain how protein is made using information from DNA (M= 2.98, SD= 0.89), Describe how the nervous system coordinates and regulates these feedback mechanisms to maintain homeostasis (M= 2.93, SD= 0.83). It can be deduced that the students are moving towards mastery in the concepts of the reproductive system and their functions, role of hormones, feedback mechanisms, protein synthesis, and homeostasis.

Although moving toward there were also lower means obtained in the following indicators: Explain the occurrence of evolution (M=2.73, SD=0.93), Explain how species diversity increases the probability of adaptation and survival of organisms in changing environments (2.75, SD= 0.90), Explain the relationship between population growth and carrying capacity (M= 2.81, SD= 0.88). This implies that the respondents may further in hands their conceptual understanding in the occurrence of evolution, species diversity, and population growth and carrying capacity.

Based on the open-ended question, the lowest mastery that the students have among the grade 10 biology competencies are in explaining how species diversity increases the probability of adaptation and survival of organisms in changing environments (f=7) and the explanation on the occurrence of evolution (f=5). The reasons of the lowest mastery of the students include the poor prior knowledge about the topic, lack of interest, depression, poor computational skills, poor conceptual understanding, and poor retention, not thoroughly discussed by the teacher and short period of time.

Students often lack requisite background knowledge, even if the educators provides the conducive environment to learn and support critical scientific thinking and reaasoning to do effectively (Anderman et al., 2012). In the study of Kempa (2006), lack of interest, and inadequacy of effort and attention are other reasons responsible in prevailing students to fail on learning. According to Lazarowitz and Penso (1992), the learners encountered difficulty in determing the mutual relationship between several facts or collection of data but succeeded in explaining the impact of one isolated fact.

Table 7 shows the summary of least mastered competencies in biology of Grade 10 students in each grade level competencies.

Table 7. Summary of least mastered competencies in biology of grade 10 students

Biology competencies	Overall mean	SD	Description	Rank
Grade 7	2.44	0.49	LM	2
Grade 8	2.67	0.60	MTM	3
Grade 9	2.31	0.54	LM	1
Grade 10	2.96	0.66	MTM	4

Legend: M- Mastered (3.50-4.00), MTM- Moving Towards Mastery (2.50-3.49), LM- Low Mastery (1.50-2.49), NM- No Mastery (1.00-1.49)

The result showed Grade 9 biology competencies ranked first in the table and obtained the lowest mastery with an overall mean of 2.31 and a standard deviation of 0.54. Grade 9 biology competencies obtained a lowest mastery with an overall mean of 2.31 and a standard deviation of 0.54. The topics that are included are Respiratory System, Circulatory System, Genetics, Photosynthesis and Respiration. It implies that they are not interested in the topics that is why it can affect the students' learning process. Grade 7 biology competencies obtained a lowest mastery with an overall mean of 2.44 and a standard deviation of 0.49. Grade 8 biology competencies obtained a moving towards mastery with an overall mean of 2.67 and a standard deviation of 0.60. Grade 10 biology competencies also obtained a moving towards mastery with an overall mean of 2.96 and a standard deviation of 0.66. The topics that are included the Reproductive System, Nervous System, Heredity& Evolution and Biodiversity.

Learning and schooling is not only worth listening perhaps the most important foundation is thinking about ways of improving schools, teaching and learning based on what the students say about education. The difficulty level depends on the understanding of a learners. In Grade 9 Biology is a time where in you start learning about the concepts in life that you need in your entire life (Etobro & Fabinu, 2017).

A one-way analysis of variance between groups was done to explore the impact of the profile variables on the competency mean scores in grade 7 biology (Table 8).

Table 8. One-way analysis of variance of the respondents' least mastered competencies in grade 7 biology by profile variables

Source	SS	Df	MS	F	p-value
School					
Between Groups	1.896	2	.948	4.090	0.019*
Within Groups	27.587	119	.232		
Total	29.483	121			
Age					
Between Groups	.010	2	.005	.020	0.980
Within Groups	29.473	119	.248		
Total	29.483	121			
Sex					
Between Groups	1.172	1	1.172	4.954	0.028*
Within Groups	28.147	119	.237		
Total	29.318	120			

** Significant at p<0.050* **equal variances assumed*

As shown in Table 8, there was a significant difference in the students' least mastered competencies in Grade 7 Biology according to school at the 0.05 level [F (2,119) = 4.090, p<0.05]. Post-hoc comparison using Tukey LSD test indicated that significant differences were found between School A (M= 2.75) and School B (M= 2.38); and between School A (M= 2.75) and School C (M= 2.41). This means that students in School A have higher mastery in Grade 7 biology competencies compared with School B and School C.

There is also have significant difference in the students' least mastered competencies in Grade 7 Biology according to sex at the 0.05 level [F (2,119) = 4.954, p<0.05]. Female respondents (M= 2.53) have a higher mastery compared to male respondents (M=2.33) of Grade 7 Biology competencies.

The computed p-value for age (0.980) is higher than (>) 0.05 level of significance, thus the null hypothesis is accepted. Hence, there were no statistically significant differences at the 0.05 level of significance in the rating mean scores of the respondents. There is no adequate evidence to show statistically significant differences in the respondents' rating in the least mastered competencies in Grade 7 Biology relevance by profile variables which possibly due to the small sample size taken or might be due to the large error of measurement.

Based from the mean analysis, as to age, students in 15- below (M= 2.45) indicated higher mastery on Grade 7 Biology competencies while those students age 18- above (M= 2.41) indicated lower mastery on Grade 7 Biology competencies. According to Reddy (2017), in grade 7 Biology 15- below have much higher mastery because of attitude toward learning in Science and they are more focused in scientific subject. Table 9 shows the difference in the respondents' least mastered competencies in grade 8 Biology when grouped according to profile variables.

Table 9. One-way analysis of variance of the respondents' least mastered competencies in grade 8 biology by profile variables

Source	SS	Df	MS	F	p-value
School					
Between Groups	2.002	2	1.001	3.586	0.031*
Within Groups	33.218	119	.279		
Total	35.220	121			
Age					
Between Groups	.196	2	.098	.333	0.718
Within Groups	35.024	119	.294		
Total	35.220	121			
Sex					
Between Groups	.263	1	.263	.902	0.344
Within Groups	34.684	119	.291		
Total	34.947	120			

** Significant at p<0.050* **equal variances assumed*

As shown in the Table 9, there was a significant difference in the students' least mastered competencies in Grade 8 Biology according to school at the 0.05 level [F (2,119) = 3.586, p<0.05]. Post-hoc comparison using Tukey LSD test indicated that significant differences were found between School A (M= 2.59) and School B (M= 2.22). This means that students in School A have higher mastery in Grade 8 biology competencies compared with School B. The computed p-value for age (0.718) and sex (0.344) are higher than (>) 0.05 level of significance, thus the null hypothesis is accepted. Hence, there were no statistically significant differences at the 0.05 level of significance in the rating mean scores of the respondents. There is no adequate evidence to show statistically significant differences in the respondents' rating in the least mastered competencies in Grade 8 Biology relevance by profile variables which possibly due to the small sample size taken or might be due to the large error of measurement.

Based from the mean analysis, as to age students in 18- above (M= 2.38) indicated higher mastery on Grade 8 Biology competencies while those aged 16-17 (M= 2.28) indicted lower mastery on Grade 8 Biology competencies. According to Pem (2019), age 18 and above are much attentive in learning process in Biology they can easily adopt the topic of Biology than age 15- below. As to sex, female (M= 2.76) indicated higher mastery on Grade 8 Biology competencies than to male (M=2.55).

A one-way analysis of variance between groups was done to explore the impact of the profile variables on the rating mean scores in grade 9 biology competencies (Table 10).

Table 10. One-way analysis of variance of the respondents' least mastered competencies in grade 9 biology by profile variables

Source	SS	Df	MS	F	p-value
School					
Between Groups	2.137	2	1.069	3.063	0.050*
Within Groups	41.518	119	.349		
Total	43.655	121			
Age					
Between Groups	1.059	2	.530	1.480	0.232
Within Groups	42.596	119	.358		
Total	43.655	121			
Sex					
Between Groups	1.314	1	1.314	3.702	0.057
Within Groups	42.228	119	.355		
Total	43.542	120			

** Significant at p<0.050* **equal variances assumed*

As shown in the Table 10, there was a significant difference in the students' least mastered competencies in Grade 9 Biology according to school at the 0.05 level [F (2,119) = 3.063, p<0.05]. Post-hoc comparison using Tukey LSD test indicated that significant differences were found between School A (M= 2.75) and School B (M= 2.38); and between School A (M= 2.75) and School C (M= 2.41). This means that students in School A have higher mastery in Grade 9 biology competencies compared with School B and School C.

The computed p-value for age (0.232) and sex (0.057) are higher than (>) 0.05 level of significance, thus the null hypothesis is accepted. Hence, there were no statistically significant differences at the 0.05 level of significance in the rating mean scores of the respondents. There is no adequate evidence to show statistically significant differences in the respondents' rating in the least mastered competencies in Grade 9 Biology relevance by profile variables which possibly due to the small sample size taken or might be due to the large error of measurement.

Based from the mean analysis, as to age students in 18- above (M=2.81) indicated higher mastery on Grade 9 Biology competencies while those aged 15-below (M= 2.78) indicated lower mastery on Grade 9

Biology competencies. As to sex, female (M= 2.76) indicated higher mastery on Grade 9 Biology competencies than to male (M=2.55). The higher preference for biology is female while boys are more inclined in Physics and Chemistry, which is why females had higher mastery of Grade 8 Biology (Reddy, 2017). Table 11 shows the difference in the respondents' least mastered competencies in Grade 10 Biology when grouped according to profile variables.

Table 11. One-way analysis of variance of the respondents' least mastered competencies in grade 10 biology by profile variables

Source	SS	Df	MS	F	p-value
School					
Between Groups	.976	2	.488	1.111	0.333
Within Groups	52.268	119	.439		
Total	53.243	121			
Age					
Between Groups	.707	2	.353	0.800	0.452
Within Groups	52.537	119	.441		
Total	53.243	121			
Sex					
Between Groups	2.088	1	2.088	4.872	0.029*
Within Groups	50.991	119	.428		
Total	53.079	120			

** Significant at p<0.050* **equal variances assumed*

As shown, there was a significant difference in the students' least mastered competencies in Grade 10 Biology according to sex at the 0.05 level [F (2,119) = 4.872, p<0.05]. Female (M= 2.81) have a higher mastery compared to male respondents (M=2.33) of Grade 10 Biology competencies. The computed p-value for age (0.452) and school (0.333) are higher than (>) 0.05 level of significance, thus the null hypothesis is accepted. Hence, there were no statistically significant differences at the 0.05 level of significance in the rating mean scores of the respondents.

There is no adequate evidence to show statistically significant differences in the respondents' rating in the least mastered competencies in Grade 10 Biology relevance by profile variables which possibly due to the small sample size taken or might be due to the large error of measurement. Research revealed that promoting conceptual change and engaging in deep reflective thinking plays a pivotal role as students motivation in science learning in Grade 10 and are instrumental in enhancing students science attainment (Ali, 2012). Table 12 shows the relationship among the biology competencies per grade level.

Table 12. Correlation between the relationships among biology competencies variables

Variables	Grade 7	Grade 8	Grade 9	Grade 10
Grade 7	-			
Grade 8	0.667**	-		
Grade 9	0.587**	0.602**	-	
Grade 10	0.374**	0.377**	0.595**	-

*** Correlation is significant at the 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

As shown from the table above, inter-correlations among all the competencies in Biology of Grade 10 students are positive moderately and low. In particular, there is a significant positive moderate correlation between Grade 8 least mastered competencies and Grade 7 least mastered competencies (r=0.667; p<0.01) which implies that when students have moderately least mastered competencies in Grade 8 Biology they will likely have least mastered competencies in Grade 7 Biology. There is also positive significant moderate correlation between Grade 9 least mastered competencies and Grade 8 least mastered competencies (r=0.602; p<0.01) implying that when students have least mastered competencies in Grade 9, they will have least mastered competencies in Grade 8.

Moreover, there is a moderate correlation between Grade 10 least mastered competencies and Grade 9 least mastered competencies of students (r=0.595; p<0.0) it indicates that when students have least mastered competencies in Grade 10 Biology, they will also have least mastered competencies in Grade 9 Biology. It can also be noted that there is a significant positive moderate correlation between Grade 9 least mastered competencies and Grade 7 least mastered competencies (r=0.587; p<0.01), implying that when the students have least mastered competencies in Grade 9 Biology, they will also have least mastered competencies in Grade 7 Biology.

Although statistically significant, there is also low correlation between Grade 10 least mastered competencies and Grade 7 least mastered competencies (r=0.374; p<0.01) implying that when the students have least mastered competencies in Grade 10 Biology, they will also have least mastered competencies in

Grade 7 Biology. It can also be noted that there is low correlation between Grade 10 least mastered competencies and Grade 8 least mastered competencies ($r= 0.377$; $p< 0.01$) it implies that when the students have least mastered competencies in Grade 10 Biology, they will also have least mastered competencies in Grade 8 Biology.

According to Miller (1963), high school biology is imparted to Grade 9th grade students, some evidence for moving the biology class own from the 10th grade suggests that 9th grade students of biology show little difference in achievement when compared to 10th grade students of biology. It said also that if 8th grade can be easily understood; chances are quite good in 7th grade.

A proposed instructional intervention program was crafted based on the least mastered competencies in Biology. The intervention is composed of the least mastered competencies, proposed pedagogical strategies, suggested learning tasks and assessment tasks. Table 13 shows the proposed instructional intervention in the least mastered competencies (LMCs) in Grade 7 Biology.

Table 13. Proposed instructional intervention in the least mastered competencies in Grade 7 Biology

Least mastered competencies/ code	Pedagogical strategies	Learning task	Assessment task
• Focus specimens using the compound microscope ***(S7LT-IIa-1).***	Flipped Classroom Strategy	The students will conduct simple research at home on how to use the microscope properly and perform it in the class after.	Performance-based tasks.
• Explain why the cell is considered the basic structural and functional unit of all organisms ***(S7LT-IIe-5).***	Cell parts 3D Visual Simulation	Cell parts virtual dissection	Worksheet
• Predict the effect of changes in abiotic factors on the ecosystem (***S7LT-IIh-9).***	Brain storming strategy	The students will share their knowledge about environmental events or dilemmas which showcase connection on biotic and abiotic factors in the environment.	Presentation of outputs.

There are three suggested pedagogical strategies to address the students' LMCs. Flipped classroom strategy will be utilized to address the competency on focusing specimens using the compound microscope. The idea of flipped classroom strategy is that what is done at home as conventional learning is done in the classroom, and what is done in the classroom as conventional learning is done at home (Bergmann & Sams, 2012).The Cell Parts 3D visual simulation will be used to explain why the cell is considered the basic structural and functional unit of all organisms. Computer-based simulations for scientific learning can be utilized to develop procedural knowledge for doing lab operations as well as conceptual knowledge for comprehending and explaining the demonstration, but further study on their educational efficacy is needed (Honey & Hilton, 2011). Brain storming strategy is proposed as an intervention to be used to predict the effect of changes in abiotic factors on the ecosystem. Brainstorming is one of the most distinctive ways to develop creative thinking, so the nature of the brainstorming is characterized as working on the flow of ideas without criticism and try to speed thinking, break the deadlock, and challenge the mind (Malkawi & Smadi, 2018).

Table 14. Proposed instructional intervention in the least mastered competencies in Grade 8 Biology

Least mastered competencies/code	Pedagogical strategies	Learning task	Assessment task
• Classify organisms using the hierarchical taxonomic system ***(S8LT-IVh20).***	Gallery walk	Going around inside the classroom while looking on the pictures that are pasted on the wall which showcase scientific classification of different organisms.	Moving exam
• Explain the significance of meiosis in maintaining the chromosome number ***(S8LT-IVe17).***	Visual simulation	The students will use a technology or computer for them to see the realistic graphical representation of meiosis.	Computer mediated Quiz
• Explain ingestion, absorption, assimilation, and excretion ***(S8LT-IVa13).***	Mini Anchor Charts	The teacher will show the students process of the ingestion, absorption, assimilation and excretion.	Short quiz

As presented in the Table 14, there are three suggested pedagogical strategies to address the students' LMCs. Gallery walk strategy will be utilized to address the least mastered competency on classifying organisms using the hierarchical taxonomic system. Posters or pictures are displayed around the room for a gallery walk so all groups can see other groups' work (Patterson & Gray, 2019). While reviewing the posters or pictures, each group can check new learnings from the materials posted. The visual simulation strategy could be used to explain the significance of meiosis in maintaining the chromosome number. Visual simulation may connect real-world actions with comparable learning settings and procedures in future academic and professional employment (Kelly et al., 2014). The Mini Anchor Charts is proposed as an intervention to be used to explain ingestion, absorption, assimilation, and excretion. An anchor chart "primarily serves teachers and students in a large written form a space where factual information is visually represented to increase comprehension of, for example, a process, living cycle and/or for vocabulary building" (Garza & Cavazos, 2020). Table 15 shows the proposed instructional intervention in the least mastered competencies (LMCs) in Grade 7 Biology.

Table 15. Proposed instructional intervention in the least mastered competencies in Grade 9 Biology

Least mastered competencies/code	Pedagogical strategies	Learning task	Assessment task
• Explain the different patterns of non-Mendelian inheritance ***(S9LT-Id-29).***	Guided Discovery Problems	Debugging the different parts of the process.	Problem solving.
• Relate species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment ***(S9LT-Ie-f30).***	Argument-based Science Inquiry	The students will watch video documentaries that will showcase the different species extinction which is related on the failure of population.	Reflection paper
• Differentiate basic features and importance of photosynthesis and respiration ***(S9LT-Ig-j3).***	Field work	The students will go outside the classroom and will observe how photosynthesis and respiration happen.	Laboratory report

The suggested pedagogical strategies to address the students' LMCs in Grade 9 biology are guided discovery problems, argument-based science inquiry, and fieldwork. Guided discovery problems can be used to explain the different patterns of non-Mendelian inheritance. Guided discovery problems encourage learners' natural curiosity and inquisitiveness (Ignisha et al, 2021) specifically in science. Argument-based science inquiry is proposed to address the competency on relating species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment. It is an approach designed to engage students in inquiry science, argumentation, and experimentation as science learning process and improving critical and creative thinking skills (Taylor et al., 2018). Field work is suggested as an intervention to be used to differentiate the basic features and importance of photosynthesis and respiration. Field work is the "process of observing and collecting data about people, cultures, and natural environments" which is mostly used in scientific disciplines. Table 16 shows the proposed instructional intervention for grade 10 Biology.

Table 16. Proposed instructional intervention in the least mastered competencies in Grade 10 Biology

Least mastered competencies/code	Pedagogical strategies	Learning task	Assessment task
• Explain the occurrence of evolution ***(S10LTIIIg-40).***	Multi-flow Maps	The students will show the cause and effect of an event through a map.	Use of rubrics as assessment tool.
• Explain how species diversity increases the probability of adaptation and survival of organisms in changing environments ***(S10LTIIIh-41).***	Role Playing	The students will get a role of an organism in the environment that will showcase their way of adapting and surviving on the changing environments.	Performance based which is guided by a scoring rubric.
• Explain the relationship between population growth and carrying capacity ***(S10LTIIIi-42).***	Fishbone	Students need to know the cause and effect of the population growth and carrying capacity. The head of the fish will stand for the change the body will serve as the reason and the fish tail for the supportive evidence.	Presentation of the outputs.

There are suggested pedagogical strategies to address the students' LMCs. Multi flow maps could be used to address the competency on explaining the occurrence of evolution. The multi-flow map is a conceptual map that is used to highlight the interconnections between events as well as the reasons of an occurrence, which are displayed on the left side. Role playing is proposed as an intervention to be used to explain how species diversity increases the probability of adaptation and survival of organisms in changing environments. Role-playing promotes the students' contextual understanding of the scientific and social concepts and processes

(Sagmeister et al., 2021). Fishbone strategy is proposed to address the relationship between population growth and carrying capacity. A fishbone diagram is a visual way to look at cause and effect.

The proposed pedagogical strategies embedded in the instructional intervention is deemed necessary to enhance the least mastered competencies of students in biology. This intervention plan can be migrated online as schools have shifted to flexible learning and distance learning due to the COVID-19 pandemic. The effectiveness of the pedagogical strategies may address the current situation of biology education in the current global health crisis.

CONCLUSION

The study determined the least mastered competencies of Grade 10 students in the biology competencies based on the different grade levels from grade 7 to grade 10. The Grade 7 and Grade 9 biology competencies in the K12 science curriculum gained the lowest mastery among the Grade 10 students. There was significant difference in the students least mastered competencies according to school and sex. There was a significant relationship among the variables of least mastered competencies in biology. Science teachers may consider employing inquiry-based, and hands-on learning activities to further enhance students' proficiency in science and decrease their difficulty of subject matter. Teachers can design varied motivational activities to engage the students in the science learning process fully dents may be given drills and brain exercises regarding scientific concepts and principles for better retention. Teachers may design activity to explore prior understanding of students and solicit their alternative conceptions and misconceptions. The proposed instructional intervention may be implemented by science teachers to minimize students' difficulties in learning science. Administrators may send the science teachers to seminars and workshops to update their content knowledge and pedagogy in science. Teachers may also consider students' affective dimension in designing learning tasks and selecting assessment tools. Since the study was conducted before the COVID-19 pandemic period, further study may also look into the least mastered competencies of the students in biology during the COVID-19 educational disruption. The most essential learning competencies (MELCs) identified by the Department of Education (DepEd) may also be used as a framework to identify the least mastered competencies in biology.

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REFERENCES

Ali, T. (2012). A case study of the common difficulties experienced by high school students in chemistry classroom in Gilgit-Baltistan (Pakistan). *SAGE Open*, *2*(2), 2158244012447299. https://doi.org/10.1177/2158244012447299

Aliaga, M., & Gunderson, B. (2000). Introduction to quantitative research. Doing quantitative research in education with SPSS (pp. 1–11). Thousand Oaks, CA: Sage. https://doi.org/10.4135/9781849209014.n1

Anderman, E. M., Sinatra, G. M., & Gray, D. L. (2012). The challenges of teaching and learning about science in the twenty-first century: Exploring the abilities and constraints of adolescent learners. *Studies in Science Education*, *48*(1), 89-117. https://doi.org/10.1080/03057267.2012.655038

Antipolo, A. M. R., & Rogayan, D. V. Jr. (2021). Filipino prospective teachers' experiences in teaching in K12 science curriculum: A cross-sectional research. *Jurnal Pendidikan Biologi Indonesia, 7*(1), 1-10. https://doi.org/10. 2022219/jpbi.v7i1.15468

Ardan A. S., Ardi, M., Hala, Y., Supu A., & Dirawan G. D. (2015). Needs assessment to development of biology textbook for high school class x-based the local wisdom of Timor. *International Education Studies, 8*(4), 52-59. https://doi.org/10.5539/ies.v8n4p52

Awan, R.-U.-N., Sarwar, M., Naz, A., & Noreen, G. (2011). Attitudes toward science among school students of different nations: A review study. *Journal of College Teaching & Learning (TLC)*, *8*(2). https://doi.org/10.19030/tlc.v8i2.3555

Bahar M, Johnstone AH, Hansell MH (1999). Revisiting learning difficulties in biology. Journal of Biological Education, **33**(2), 84-86. https://doi.org/10.1080/00219266.1999.9655648

Baram-Tsabari A., & Yarden A. (2005). Characterizing children's spontaneous interests in science and technology. *International Journal of Science Education, 27*(7), 803–826*.* https://doi.org/10.1080/09500690500038389

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day.* International Society for Technology in Education.

Buckley, E. (2018, June 8). The importance of biology in school curriculum. *Charter Me Now.* https://chartermenow.com/the-importance-of-biology-in-school-curriculum/

Chi, S., Wang, Z., Liu, X., & Zhu, L. (2017). Associations among attitudes, perceived difficulty of learning science, gender, parents' occupation and students' scientific competencies. *International Journal of Science Education*, *39*(16), 2171-2188. https://doi.org/10.1080/09500693.2017.1366675

Çimer, A. (2004). *A study of Turkish biology teachers' and students' views of effective teaching in schools and teacher education* (Published Doctoral Dissertation). The University of Nottingham, Nottingham, U.K. https://www.researchgate.net/publication/233358366

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views? *Educational Research and Reviews, 7*(3), 61-71. https://academicjournals.org/article/article1379665422_Cimer.pdf

Cipkova E., Karolcik S., Dudova N., & Nagyova S. (2018). What is the students' interest in biology after the biology curriculum modification? *The Curriculum Journal, 29(3), 370–386.* https://doi.org/10.1080/09585176.2017.1406811

Dawson C. (2000). Upper primary boys' and girls' interests in science: Have they changed since 1980? *International Journal of Science Education, 22(6), 557–570.* https://doi.org/10.1080/095006900289660

Department of Education (DepEd). (2016). Science K to 12 Curriculum Guide. https://www.deped.gov.ph/wp-content/uploads/2019/01/Science-CG_with-tagged-sci-equipment_revised.pdf

Etobro A. B., & Fabinu O. E. (2017). Students' perceptions of difficult concepts in biology in senior secondary schools in Lagos state. *Global Journal of Educational Research, 16*(2), *139.* https://doi.org/10.4314/gjedr.v16i2.8

Foy, P., Arora, A., & Stanco, G. M. (2013). *TIMSS 2011 User Guide for the International Database.* ERIC. https://timss andpirls.bc.edu/timss2011/downloads/T11_UserGuide.pdf

Garza, E., & Cavazos, L. (2020). Shifting to an outdoor learning space: Embracing nature to support science process skills for english learners. *Journal of the World Federation of Associations of Teacher Education, 3*(3), 32-49. https://www.worldfate.org/docpdf/journal_03-03.pdf

Grosschedl, J., Mahler, D., Kleickmann, T. & Harms, U. (2014). Content related knowledge of biology teachers from secondary schools: Structure and learning opportunities. *International Journal of Science Education, 36*(14), 2335-2366. https://doi.org/10.1080/09500693.2014.923949

Honey, M. A., & Hilton, M. L. (2011). *Learning science through computer games and simulations.* Washington, DC: National Academies Press. https://doi.org/10.17226/13078

Ignisha Rajathi, G., Vedhapriyavandhana, R., Pooranam, N., & Oswalt Manoj, S. (2021). Holistic Education by breaking the binaries beyond the boundaries. *Turkish Journal of Computer and Mathematics Education*, *12*(1S), 709-717. https://www.turcomat.org/index.php/turkbilmat/article/view/2514

Kelly, M. A., Forber, J., Conlon, L., Roche, M., & Stasa, H. (2014). Empowering the registered nurses of tomorrow: Students' perspectives of a simulation experience for recognising and managing a deteriorating patient. *Nurse Education Today*, *34*(5), 724–729. https://doi.org/10.1016/j.nedt.2013.08.014

Kempa, R. F. (2006). Students' learning difficulties in science. Causes and possible remedies. *Enseñanza de las Ciencias. Revista de Investigación y Experiencias Didácticas*, *9*(2), 119-128. https://doi.org/10.5565/rev/ensciencias.4702

Lawsin, N.L.P. & Garcia, G. (2017*). Development of digital courseware in Transmission Genetics* (Published Master's Thesis). Philippine Normal University, Manila. https://pnu-onlinecommons.org/omp/index.php/pnu-oc/catalog/book/369

Lazarowitz, R., & Penso, S. (1992). High school students' difficulties in learning biology concepts. *Journal of Biological Education*, *26*(3), 215-223. https://doi.org/10.1080/00219266.1992.9655276

Malkawi, N. A. M., & Smadi, M. (2018). The effectiveness of using brainstorming strategy in the development of academic achievement of sixth grade students in English grammar at public schools in Jordan. *International Education Studies*, *11*(3), 92-100. https://doi.org/10.5539/ies.v11n3p92

Millanes, M. A. A., Paderna, E. E. S., & Que, E. N. (2017). Podcast-Integrated physics teaching approach: Effects on student conceptual understanding. *The Normal Lights, 11*(2), 60-85. https://po.pnuresearchportal.org/ejournal/index.php/normallights/article/view/527

Miller, P. E. (1963). A comparison of the abilities of secondary teachers and students biology to understand science. *Proceeding of the Iowa Academy of Science, 70(1), 510-513.* https://scholarworks.uni.edu/pias/vol70/iss1/82/

National Geographic. (n.d.). Field work. https://www.nationalgeographic.org/encyclopedia/field-work

Osborne, J., & Collins, S. (2000). Pupils' & parents' views of the school science curriculum. London: Kings College. https://www.kcl.ac.uk/archive/website-resources/education/web-files2/news-files/ppt.pdf

Ozcan, N. (2003). *A group of students' and teachers' perceptions with respect to biology education at high school level* (MA Thesis). Middle East Technical University, Ankara, Turkey. https://etd.lib.metu.edu.tr/upload/1086933/index.pdf

Patterson, A., & Gray, S. (2019). Teaching to Transform: (W)holistic science pedagogy. *Theory into Practice, 58(4), 328-337.* https://doi.org/10.1080/00405841.2019.1626616

Pem, K. (2019). *Can computer- assisted through tailored motion graphics assist in biology teaching and enhance academic results and science visual literacy in grade 8 biology learners in Mauritius?* Open University of Mauritius. https://www.semanticscholar.org/paper/Can-Computer-Assisted-Instructions

Prokop, P., Tuncer, G., & Chuda, J. (2007). Slovakian students' attitudes toward biology. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(4), 287–295. https://doi.org/10.12973/ejmste/75409

Reddy, L. (2017). Gender differences in attitudes to learning science in grade 7. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(1), 26-36. https://doi.org/10.1080/18117295.2017.1279450

Rogayan, D. V. Jr., & Dollete, L. F. (2019). Development and validation of physical science workbook for senior high school. *Science Education International*, *30*(4), 284-290. https://doi.org/10.33828/sei.v30.i4.5

Sagmeister, K. J., Schinagl, C. W., Kapelari, S., & Vrabl, P. (2020). Students' experiences of working with a socio-scientific issues-based curriculum unit using role-playing to negotiate antibiotic resistance. *Frontiers in Microbiology*, *11*. https://doi.org/10.3389/fmicb.2020.577501

Sarwar M., Naz A., & Noreen, G. (2011). Attitudes toward science among school students of different nations: A review study. *Journal of College Teaching and Learning, 8(2), 43.* https://doi.org/10.19030/tlc.v8i2.3555

Schwab, K., & Sala-i-Martín, X. (2016). *The global competitiveness report 2013–2014: Full data edition*. http://repositorio.colciencias.gov.co:8080/handle/11146/223

SEI-DOST & UP NISMED. (2011). *Framework for Philippine science teacher education.* Manila: SEI-DOST & UP NISMED. https://sei.dost.gov.ph/images/downloads/publ/sei_sciteach.pdf

Sjøberg, S., & Schreiner, C. (2010). *The ROSE project: An overview and key findings.* Oslo: University of Oslo. https://roseproject.no/network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2010.pdf

Taylor, J. C., Tseng, C. M., Murillo, A., Therrien, W., & Hand, B. (2018). Using argument-based science inquiry to improve science achievement for students with disabilities in inclusive classrooms. *Journal of Science Education for Students with Disabilities*, *21*(1), 1-14. https://doi.org/10.14448/jsesd.10.0001

Tekkaya C., Ozkan O., & Sungur S. (2001). Biology concepts perceived as difficult by Turkish High School students. *Journal of Hacettepe University Education Faculty, 21, 145-150.* http://www.efdergi.hacettepe.edu.tr/yonetim/icerik/makaleler/1048-published.pdf

TIMSS (Trends in International Mathematics and Science Study). (2013). TIMSS 2011 user guide for the international data base. Chestnut Hill, MA: Boston College. https://timssandpirls.bc.edu/timss2011/downloads/T11_UserGuide.pdf

World Economic Forum (2014). Global competitiveness report. https://reports.weforum.org/global-competitiveness-report-2014-2015/

Zeidan A. (2010). The Relationship between grade 11 Palestinian attitudes toward biology and their perceptions of the biology learning environment. *International Journal of Science and Mathematics Education, 8(5), 783–800.* https://doi.org/10.1007/s10763-009-9185-8