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Development of Grade-10 Students' Conceptual Understanding of Dot Structure and Molecular Shape from Learning by Using Magnet and Pin Kits

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Abstract. This research aims to develop grade 10 students' conceptual understanding of the topic of dot structure and molecular shape from learning by using the Magnet and Pin kits. The research methodology is one group pretest-posttest design. The participants are 33 grade 10 students from a school in Khon Kaen province (Thailand), acquired by purposive sampling. The data was collected using the Dot structure and Molecular shape Conceptual Test (DMCT). The DMCT will be used to collect data for the pre-test and post-test. There are six items in the DMCT (difference in six molecular formulas; PF_5, ClO_4^-, CO_3^{2-} ,O_3, ClF_3, and $XeOF_4$). The answers form DMCT were analyzed by classifying the conceptual understanding at 5 levels according to the conceptual framework of Çalik, Ayas, and Coll (2009). The results found that before learning, most of the students had a conceptual understanding at the NU level of the ClO_4^-, CO_3^{2-} ,O_3, ClF_3, $XeOF_4$ molecule and had SAC level understanding of the PF_5 molecule. It showed that the students' conceptual understanding of all molecules was very low. After learning with the Magnet and Pin kits, most of the students' conceptual understanding level increased to the SU level for the PF_5, CO_3^{2-}, ClF_3 and $XeOF_4$ molecules and increased to the PU level for the O_3 and ClO_4^- molecule. This shows that the use of Magnet and Pin kits in learning to draw the Lewis dot structure and to make molecular shape prediction can help students achieve an overall higher level of conception from NU & SAC to SU & PU levels. The students could specify the type and number of central atoms, surrounding atoms, number of bond pair electrons, and lone pair electrons. The students could also draw the Lewis dot structure correctly and they could draw images to represent three-dimensional shapes of molecules and correctly specify the names of molecular shapes.

Keywords: Conceptual understanding, Magnet and Pin kits, Dot structure, Molecular shape

INTRODUCTION

From the researcher's teaching experience, many students say that "Chemistry is a difficult subject", which is consistent with the analysis of science educators. This explains the reasons for the difficulty of chemistry in 3 reasons: 1) The content is abstract. Some things are not visible to the naked eye, such as atoms and molecules. 2) There is a language barrier that hinders the learner's understanding of the subject. This includes the use of specific vocabulary that has a different meaning from the meaning of the same words in everyday life. The use of various symbolic languages such as formulas, equations, constants, the use of a foreign language, namely, English, and 3) the learning arrangements conflict with the nature of learners' learning, that is, teaching is focused on the transmission of content from the teacher to the student instead of focused on the learning process (Wichaidit, 2015). The content that is difficult for students to understand is covalent bonds, which has various foundational subtopics that must be understood first, such as, drawing a Lewis dot structure leading to drawing a line structure, specification of bond types (single bond, double bond, triple bond) and prediction the molecular shapes by using the Valence Electron Pair Repulsion (VSEPR) theory.

The Lewis dot structure is used to describe the bonding between atoms that form the compounds. For covalent compounds, the Lewis dot structure is used to represent the formation of covalent bonds between the non-metal atoms in the covalent molecules. The dots are used instead of the valence electrons that are shared between atoms. The Lewis dot structure leads to the prediction of the three-dimensional shape of the molecule by using the VSEPR theory. This theory assumes that the electrostatic repulsion between valence electrons in bonding causes the surrounding atoms to remain as far apart as possible. In the case of the molecule that has the lone pair electrons on the central atom, the repulsion between lone pair electrons and bond pair electrons causes changes in the molecular shape and bond angle. The molecular shape is divided into two categories, according to whether or not the central atom has lone pair electrons. In the case of molecules in which the central atom has no lone pair electrons, these molecules have the general formula AB_x, where A is the central atom, B is the surrounding atom and x is the number of the surrounding atom. In most cases, x is between 2 to 6. In the case of molecules in which the central atom has lone pair electrons, these molecules are designated the general formula as AB_xE_y, where A is the central atom, B is the surrounding atom, x (may vary from 2 to 4) is the number of the surrounding atom, E is the symbol for the lone pair electron on the central atom and y (may vary from 1 to 3) is the number of lone pair electrons (Chang, 2010).

In the high school curriculum, the topic of the Lewis dot structure is necessary for students in the understanding of chemical bonding. The skill of dot structure drawing is an ability that the students must have. The Lewis dot structure is necessary for understanding the formation of chemical bonds, which will help the students to predict the molecular shape leading to understanding of the properties of matter, e.g., polarity, intermolecular force, solubility, melting point, and boiling point. Even though it is necessary, many books on general chemistry do not represent the Lewis dot structure in a simple manner. This lack of a simple explanation causes difficulties for many students when they try to represent molecules (Pardo, 1989). There are many studies on how to present an easy-to-understand method of the Lewis dot structure teaching, e.g., the $6N+2$ rule (Zandler and Talaty, 1984), the step-by-step approach (Ahmad and Omar, 1992), the direct electron pairing approach (Ahmad and Zakaria, 2000), the use of the tactile magnets packaged model (Kimball, 2012), the use of the atomic tile model (Kiste et al., 2016), the use of the pipe cleaner and plastic bead model (Turner, 2016).

The students' misconceptions of the dot structure and molecular shape were similar to the misconceptions mentioned by previous researchers. For example, the student's misconception of the dot structure and molecular shape may be as follows: The central atom can be any element, but the number of valence electrons of the completed central atom is eight. The Lewis dot structure is drawn only for bond pair electrons to complete the octet according to the Octet rule. The Molecular shape depends on the polarity of the molecules. The H_3O^+ molecule has no lone pair electron because it has a charge (Urasin and Supasorn, 2011). The students were unsure as to which atom to choose as the central atom and the number of lone pair electrons. Students did not understand how lone pairs electrons affect the molecular shape. The BF_3 molecule is a T-shape even though the B atom has no lone pair electrons. Students drew the NH_3 and PH_3 molecules as a T-shape because they understood that there is only one lone pair electron at the N and P atoms. The students did not specify the bond angles in molecular shapes (Sunson and Wuttisela, 2015).

From the researcher's observation, it was found that many students were confused when drawing the Lewis dot structure of complex structured molecules. Students are unable to imagine the correct molecular shape only by memorizing the names of molecular shapes. Most of the students with a good ability in learning science have private science tutoring in addition to learning in the classroom. Therefore, these students may neglect to understand deeply in class. This occurrence corresponds to the observation in the work of Supatchaiyawong, Faikhamta, and Suwanruji (2015).

According to related research studies, it was known that the use of models for hands-on activities encourages discussion among teachers, students, and peers within the group. The models quickly reveal preconceptions and misconceptions as well as increase the time used to think (Wuttisela, 2014). Model-based learning activities could enhance the students' mental model and informed understanding of the nature of the model according to the scientific model (Supatchaiyawong, Faikhamta, and Suwanruji, 2015). The students had significantly higher scientific conceptual understanding after the study than before (Sunson and Wuttisela, 2015).

The examples of using the models for teaching chemical bonds are as follows: The tactile magnets packaged model was used to construct the Lewis dot structure and the ball-and-spring model kit was modified with tactile puff paint for building 3D molecular geometry (Kimball, 2012). The atomic tile model was used to create models of covalent bonding and to translate between Lewis structures and molecular models. Students who used the atomic tiles performed relatively well on the summative classroom assessment items with complex structure questions (Kiste et al., 2016). The pipe cleaner and plastic bead model was used to represent the bonding between atoms in molecules and used to consolidate the student's understanding of covalent bonding. This model proved to be highly engaging for the students and a useful stimulus for discussion (Turner, 2016). The studies mentioned above provided the inspiration for the construction of the Magnet and Pin kits used in this research study.

For the reasons mentioned above, the Lewis dot structure and molecular shape is a highly abstract content in chemistry and invisible to the naked eye and difficult to imagine. Therefore, it is necessary to find a new method of learning process that will help students see more concretely in conjunction with the reasons mentioned above. The researcher invented the Magnet and Pin kits to be used as a model for learning in the topic of Lewis dot structure and molecular shape. The goal is to give students a deeper understanding of the concepts in this regard, and not just the memorization of the content.

RESEARCH OBJECTIVE

This research aims to develop the grade 10 students' conceptual understanding of Lewis dot structure and molecular shape topics from learning by using the Magnet and Pin kits.

METHODOLOGY

This research study used the one-group pretest-posttest design. The students' understanding of the Lewis dot structure and molecular shape was interpreted from their replies to the dot structure and molecular shape conceptual test (DMCT) before and after the intervention of the Magnet and Pin kits. In addition, examples of the students' responses from the pre-test and post-test are also explained to support the classification of conceptual understanding levels.

Participants

The participants are 33 grade 10 students from a school in Khon Kaen province (Thailand) in 2nd semester of the academic year 2016, acquired by purposive sampling.

Intervention of the Magnet and Pin Kits

The Magnet and Pin Kits were developed in order to scaffold students to construct meaning of Lewis dot structure and molecular shape. The components of the Magnet and Pin kits are shown in Figure 1. The Magnet kit is made from an iron plate, alphabet letters

A and B, and circular magnets used to guide the students in drawing the dot structure of covalent molecules. After that, the shapes of the covalent molecules were generated by the Pin kit, made from a spherical eraser, pins, and droplet pins. Examples of using Magnet and Pin kits were described in the previous work of Kamkhou and Yuenyong (2019).

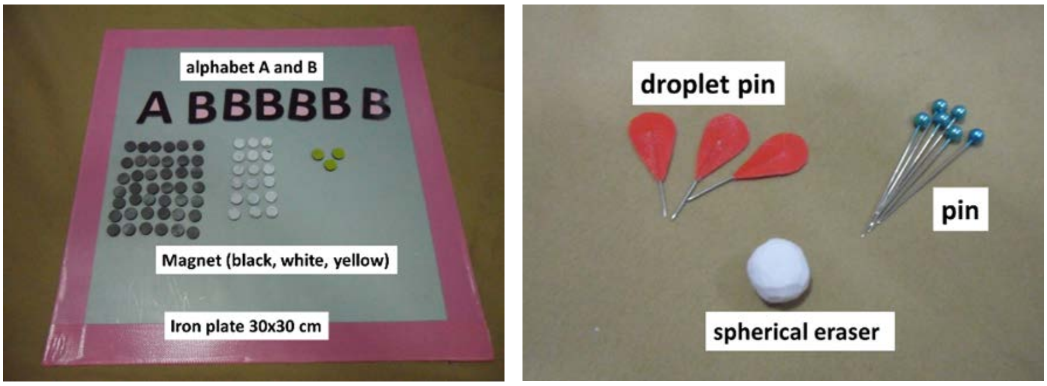

Figure 1: The components of the Magnet kit (left) and Pin kit (right)

According to Kamkhou and Yuenyong (2019), the teaching and learning about the Lewis dot structure and molecular shape through scaffolding of the Magnet and Pin Kits was provided for four steps. These included (1) examining students' existing ideas, (2) scaffolding of the Magnet and Pin kits, (3) challenging students' ideas, and (4) communicating students' ideas.

Step 1 Examining students' existing ideas: The students are given a worksheet which contains the molecular formulas CCl_4, XeF_4, and CO_3^{2-} and are instructed to draw the dot structure of each formula. The students are asked whether there were problems or difficulties. The students' responses are recorded on the board by the teacher. After that, the students are asked to match the molecular formulas of covalent compounds with 4 types of molecular shapes, namely, H_2O, CH_4, NH_3, and CO_2. The students are asked to specify which principles they used in choosing the molecular shapes. This step aims to check the students' prior knowledge.

Step 2 Scaffolding of the Magnet and Pin kits: The teacher explains how to use the Magnet and Pin kits to generate dot structures and molecular shapes of CO_3^{2-} and XeF_4 molecules, following the description in the work of Kamkhou and Yuenyong (2019).

Step 3 Challenging students' ideas: The students are taught to use the Magnet and Pin kits. The students use the Magnet and Pin kits to generate the Lewis dot structures and molecular shapes, as shown in Table 1. The teacher plays the role of a facilitator - giving advice, consulting, encouraging, and explaining the parts that the students do not understand.

Step 4 Communicating students' ideas: The teacher randomly selects students to present their dot structures and molecular shapes of molecules. Subsequently, the teacher gives feedback and summarizes the main learning concepts in the topics of the Octet rule, the Lewis dot structure drawing, and prediction of molecular shape by VSEPR theory.

Table 1: The molecular formulas for learning by using the Magnet and Pin kits

Case Study	Molecular formula	General formula	Name of molecular shape
No lone pair electrons on the central atom	NO_3^-	AB_3	Trigonal planar
	SO_4^{2-}	AB_4	Tetrahedral
	PCl_5	AB_5	Trigonal bipyramid
Contains lone pair electrons on the central atom	SO_2	AB_2E	Bent (or V-shape)
	BrF_3	AB_3E_2	T-shape
	IF_5	AB_5E	Trigonal pyramid

The Dot structure and Molecular shape Conceptual Test (DMCT)

The dot structure and molecular shape conceptual test (DMCT) was developed by the author via three steps. First, the principles of conceptual understanding test construction and test samples from various formats such as documents, books, research articles, and theses were studied to specify their suitability for the sample group. Then, the DMCT was created and validated by two high school chemistry teachers and two assistant professors in chemistry education. There are six items in the DMCT with the difference in six molecular formulas: PF_5, ClO_4^-, CO_3^{2-} ,O_3, ClF_3, and $XeOF_4$. The six molecular formulas were taken from two cases. The two cases were selected in accord with the curriculum: (1) The case of no lone pair electrons on the central atom, consisting of PF_5, ClO_4^-, and CO_3^{2-}, and (2) the case of containing lone pair electrons on the central atom, consisting of O_3, ClF_3, and $XeOF_4$. The selected molecules are comparable to those taught in the classroom (follow Table 1). All items contain four short answer questions as shown in Figure 2, consisting of (1) specifying the type and the number of central and surrounding atoms, the number of bond pair, and lone pair electrons. (2) drawing the Lewis dot structure, (3) drawing the molecular shape by specifying the bond angle, and (4) specifying the name of the molecular shape. The pre-test and post-test are the same versions but with some changes in the question order.

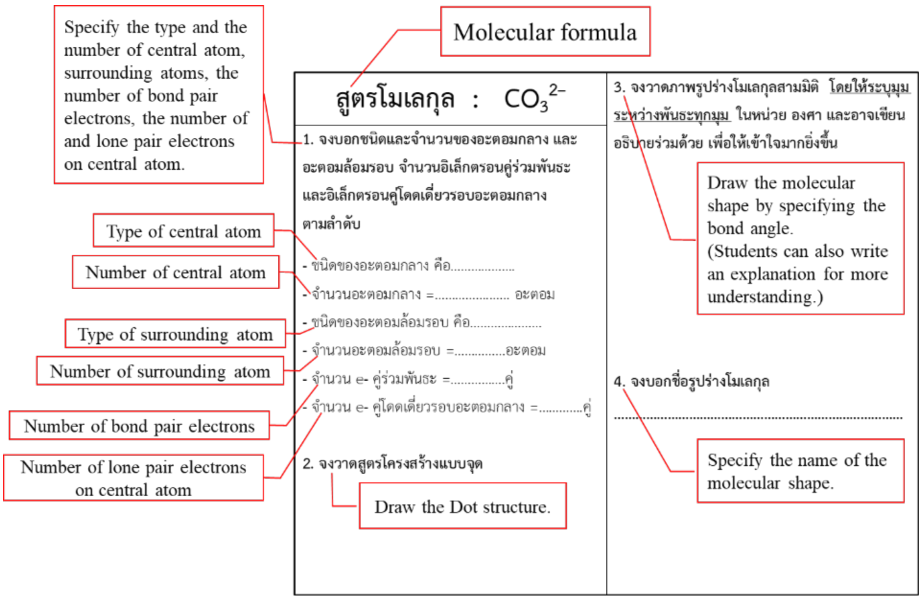

Figure 2: The example of questions in the Dot structure and Molecular shape Conceptual Test (DMCT)

Data Collection

The DMCT was used as the pre-test to determine the presence of conceptual understanding before learning. The DMCT was also used as the post-test after the learning activity with the Magnet and Pin kits to compare the conceptual understanding between the pre-test and the post-test.

Data Analysis

The students’ responses obtained from the pre-test and post-test were classified into five levels of conceptual understanding, following the work of Çalik, Ayas, and Coll (2009): Sound understanding (SU), Partial understanding (PU), Partial understanding with Specific Alternative Conception (PUSAC), Specific Alternative Conception (SAC), and No Understanding (NU). The criteria for classification are shown in Table 2. In addition, examples of the students’ responses and accompanying explanations from the pre-test and post-test are also included in the results section.

Table 2: The classification criteria of the students' conceptual understanding

Level	Classification criteria
SU	• Specify the type and number of central and surrounding atoms, the number of bond pair and lone pair electrons around the central atom are all correct 100%. • Able to draw all the Lewis dot structure correctly. • Able to draw the picture of molecular shapes along with specifying the bond angles correctly. • Specify the name of the molecular shape correctly.
PU	• Specify the type and number of central and surrounding atoms, the number of bond pair and lone pair electrons around the central atom is about 70% or higher. • Able to draw the Lewis dot structure but not completely correct. • Able to draw the picture of molecular shapes along with specifying the bond angles correctly. • Specify the name of the molecular shape correctly.
PUSAC	• Specify the type and number of central and surrounding atoms, the number of bond pair and lone pair electrons around the central atom is about 50% or higher. • Able to draw the Lewis dot structure but some parts show a lack of understanding. • Able to draw the picture of molecular shapes along with specifying the bond angles correctly but some angles show misunderstanding. • Specify the name of molecular shape correctly or the slightly inaccurate one.
SAC	• Specify the type and number of central and surrounding atoms, the number of bond pair and lone pair electrons around the central atom is less than 50%. • Draw the Lewis dot structure improperly. • Draw the picture of molecular shapes incorrectly and the bond angle is not specified. • Specify the name of the molecular shape incorrectly.
NU	• Specify the type and number of central and surrounding atoms, the number of bond pair and lone pair electrons around the central atom incorrectly or no answers. • Draw the Lewis dot structure improperly or no answers. • Draw the picture of molecular shapes incorrectly or no answers. • Specify the name of the molecular shape incorrectly or no answers.

The number of students was calculated as a percentage for each level of conceptual understanding and reported separately. In addition, examples of responses for each level are provided.

RESULTS

The student's answers from the DMCT pre-test and post-test for six individual items were classified into 5 levels of conceptual understanding, as shown in Table 3.

Table 3: The comparison of students' level of conceptual understanding for each item before and after learning with the Magnet and Pin kits

Molecular Formulas	Test	Level of conceptual understanding				
		SU number (%)	PU number (%)	PUSAC number (%)	SAC number (%)	NU number (%)
PF_5	Pre-test	0 (0.00)	1 (3.03)	1 (3.03)	**19 (57.58)**	12 (36.36)
	Post-test	**25 (75.76)**	6 (18.18)	2 (6.06)	0 (0.00)	0 (0.00)
ClO_4^-	Pre-test	0 (0.00)	0 (0.00)	0 (0.00)	13 (39.39)	**20 (60.61)**
	Post-test	8 (24.24)	**15 (45.45)**	7 (21.21)	2 (6.06)	1 (3.03)
CO_3^{2-}	Pre-test	0 (0.00)	0 (0.00)	0 (0.00)	10 (30.30)	**23 (69.70)**
	Post-test	**12 (36.36)**	**12 (36.36)**	7 (21.21)	1 (3.03)	1 (3.03)
O_3	Pre-test	0 (0.00)	0 (0.00)	0 (0.00)	10 (30.30)	**23 (69.70)**
	Post-test	8 (24.24)	**14 (42.42)**	11 (33.33)	0 (0.00)	0 (0.00)
ClF_3	Pre-test	0 (0.00)	0 (0.00)	1 (3.03)	13 (39.39)	**19 (57.58)**
	Post-test	**15 (45.45)**	5 (15.15)	11 (33.33)	2 (6.06)	0 (0.00)
$XeOF_4$	Pre-test	0 (0.00)	1 (3.03)	0 (0.00)	10 (30.30)	**22 (66.67)**
	Post-test	**11 (33.33)**	9 (27.27)	6 (18.18)	2 (6.06)	5 (15.15)

From Table 3, the analysis of students' responses from the pre-test and post-test are presented individually according to the six different molecular formulas as follows:

1. The molecular formula of PF_5

Before learning, most of the students (57.58%) had a conceptual understanding at the SAC level. For example, student number 7's answer (shown in Figure 3) revealed that the student correctly specified the type and number of the central atom and surrounding atoms (P and five F atoms, respectively), but the number of lone pair electrons on P atom (2 pairs) and the number of bond pair electrons (3 pairs) around P atom were incorrectly specified. This relates to the student drawing an incorrect Lewis dot structure, that is the two valence electrons of P atom did not share with two F atoms for bonding. When considering the molecular shape drawing, it was not related to the Lewis dot structure. It did not have a central atom and the bond angles were not specified. Also, the name of the shape was incorrect.

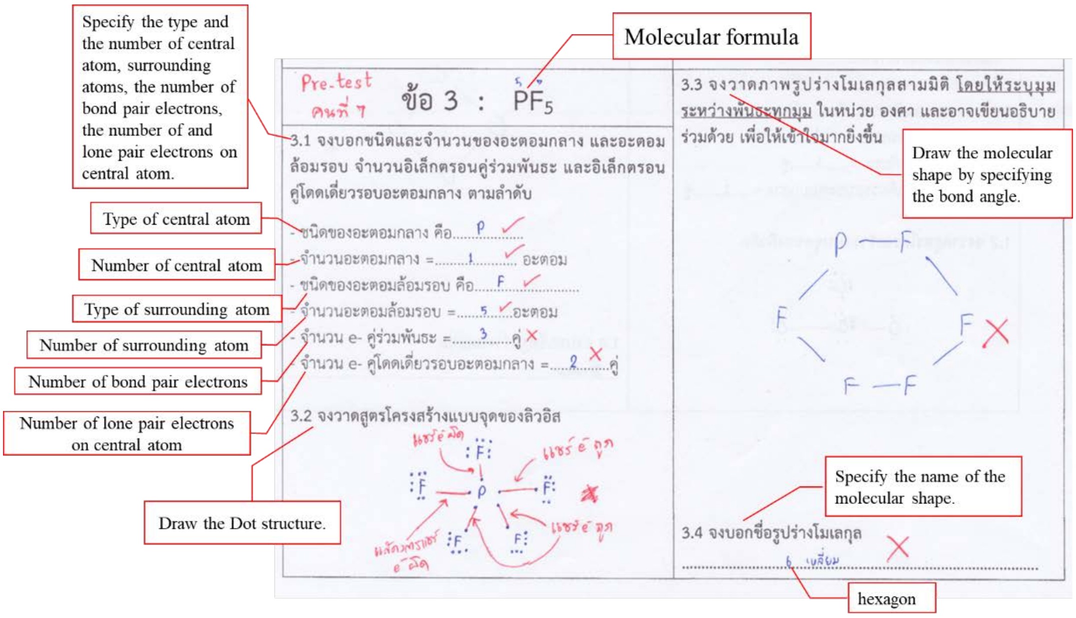

Figure 3: The students' answers of PF_5 molecule from pre-test at the SAC level (Student No. 7)

After learning with the Magnet and Pin kits, most of the students (75.76%) had a conceptual understanding at the SU level. For example, student number 3's answer (shown in Figure 4) revealed that the student could draw the correct Lewis dot structure, leading to the student correctly specifying that the P atom has no lone pair electrons due to all being used to form five bonds with the F atom. The molecular shape drawing, bond angle specifying (90^o and 120^o), and the name of the shape (trigonal bipyramid) are correct.

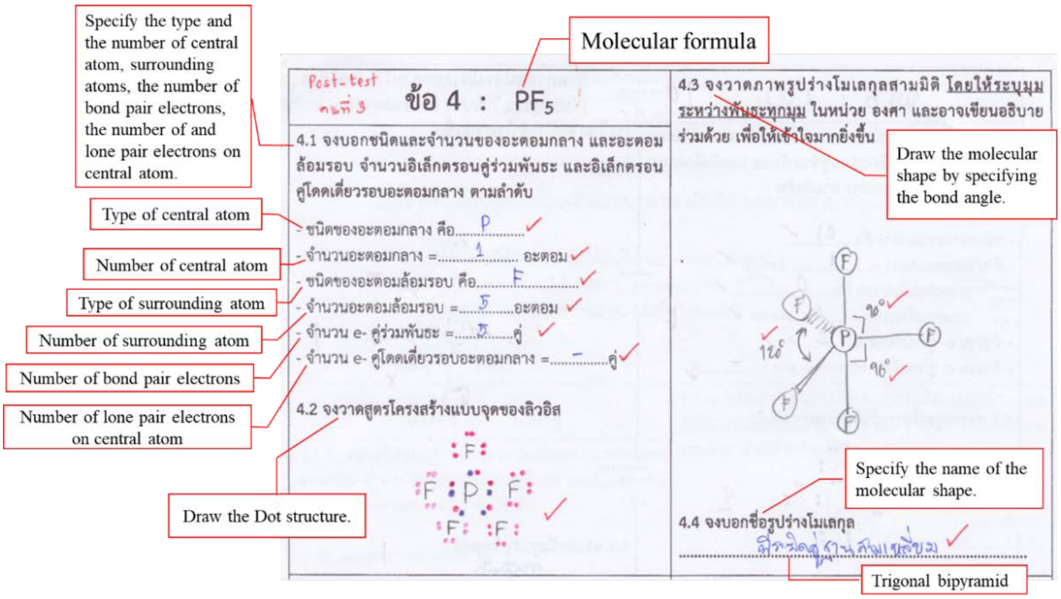

Figure 4: The students' answers of PF_5 molecule from post-test at the SU level (Student No. 3)

2. The molecular formula of ClO_4^-

Before learning, most of the students (60.61%) had a conceptual understanding at the NU level. For example, student number 1's answer (shown in Figure 5) revealed that the student incorrectly specified the O atom as the central atom but correctly specified the number of surrounding atoms for four atoms, which may be obtained by guessing from the subscript number on O atom in the ClO_4^- formula. The specification of the number of bond pair electrons (7 pairs) and lone pair electrons (6 pair) was incorrect. The molecular shape of ClO_4^- was incorrectly drawn and the name of shape was incorrect.

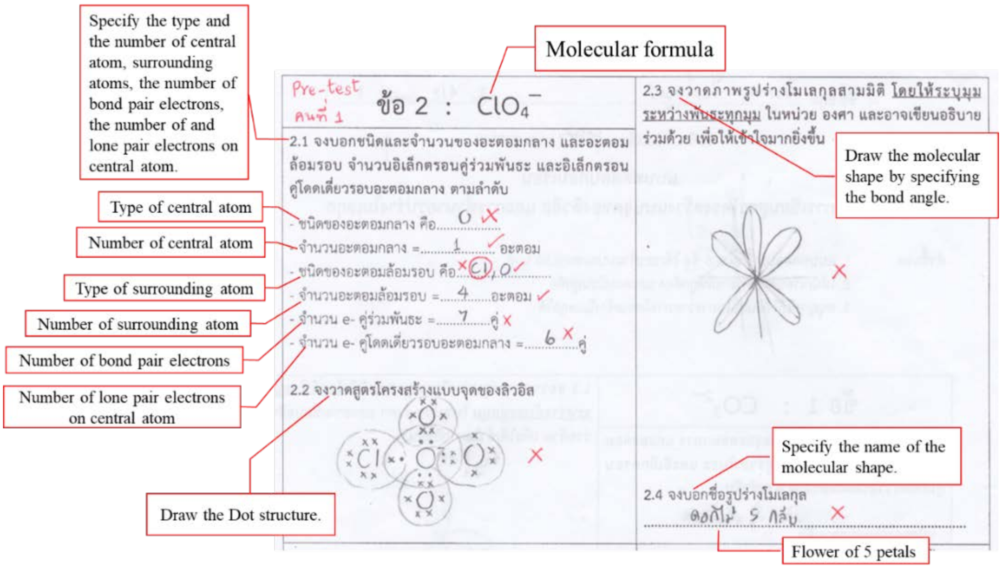

Figure 5: The students' answers of ClO_4^- molecule from pre-test at the NU level (Student No. 1)

After learning with the Magnet and Pin kits, most of the students (45.45%) had a conceptual understanding at the PU level. For example, student number 33's answer (shown in Figure 6) revealed that the student could draw the correct Lewis dot structure, which is related to correctly specifying that the Cl atom has no lone pair electrons due to all the valence electrons being used to form a covalent bond and three coordinate covalent bonds with O atoms. The drawing of the molecular shape and the name of shape (tetrahedral) were correct, but the bond angles of 90^o and 120^o were incorrect (The correct answer is ~109.5^o).

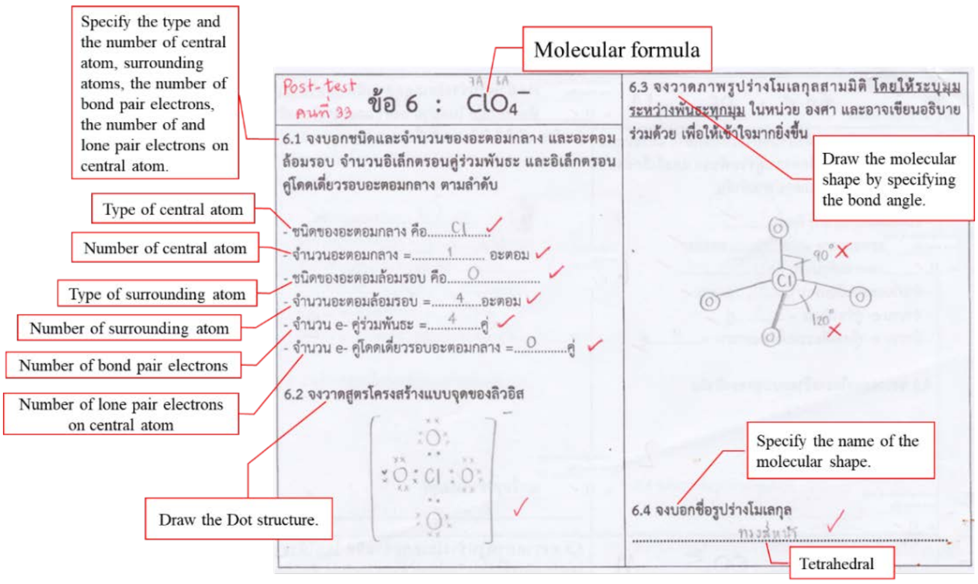

Figure 6: The students' answers of ClO_4^- molecule from post-test at the PU level (Student No. 33)

3. The molecular formula of CO_3^{2-}

Before learning, most of the students (69.70%) had a conceptual understanding at the NU level. For example, student number 31's answer (shown in Figure 7) revealed that the student correctly specified a C atom as the central atom and three O atoms as the surrounding atoms. The specification of the number of bond pair electrons (4 pairs) was correct but the number of lone pair electron (0 pair) was incorrect. The Lewis dot structure was improperly drawn due to the C atom having a lone pair electron and more than six valence electrons of the right-handed O atom. The molecular shape of CO_3^{2-} was incorrectly drawn and the name of the shape was incorrect.

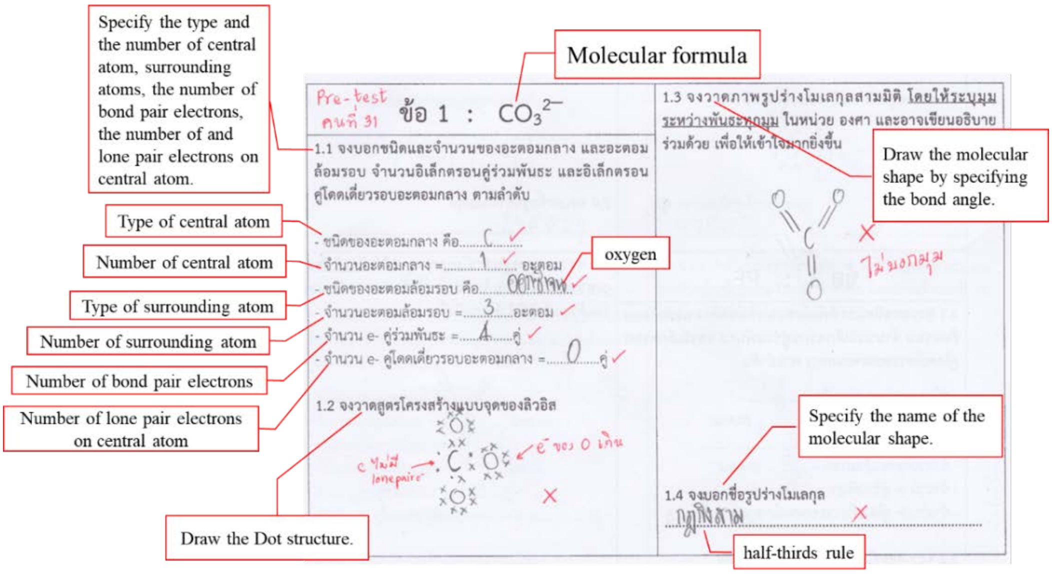

Figure 7: The students' answers of CO_3^{2-} molecule from pre-test at the NU level (Student No. 31)

After learning with the Magnet and Pin kits, the percentages of students at the PU and SU levels are the same (36.36%). For example, at the PU level, student number 26's answer (shown in Figure 8) revealed that the student could specify the C atom as the central atom and three O atoms as the surrounding atoms. The number of bond pair electrons (4 pairs) and lone pair electron (0 pair) was correct. The molecular shape and the name of the shape (trigonal planar) were correct. However, the Lewis dot structure was incompletely drawn due to more than four valence electrons on the C atom and missing six valence electrons of the left-handed O atom. While student number 20's answer (shown in Figure 9) was classified at the SU level because the answers are the same as student number 26, the Lewis dot structure was correctly drawn.

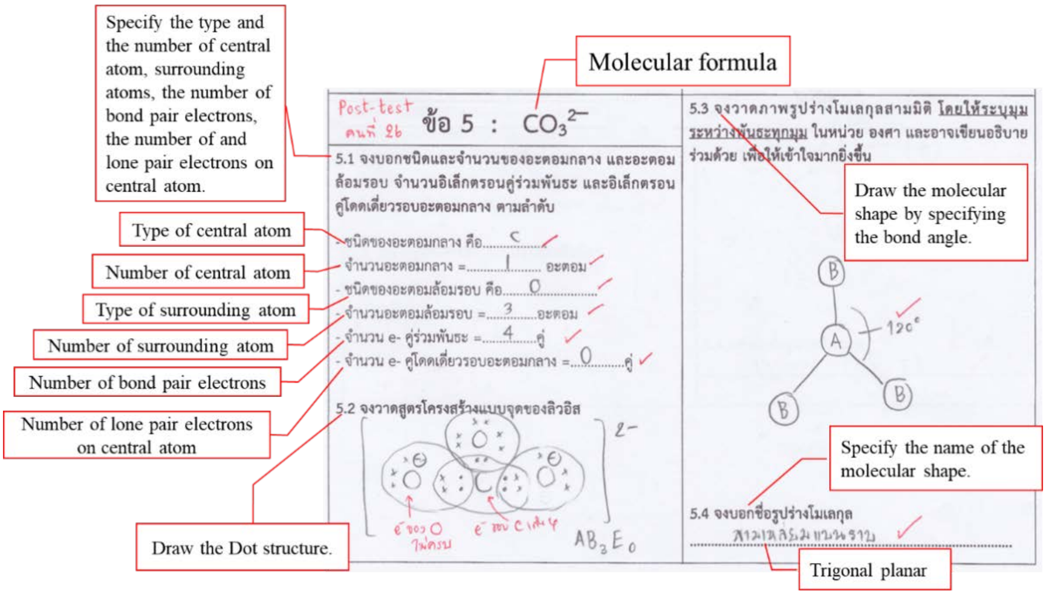

Figure 8: The students' answers of CO_3^{2-} molecule from post-test at the PU level (Student No. 26)

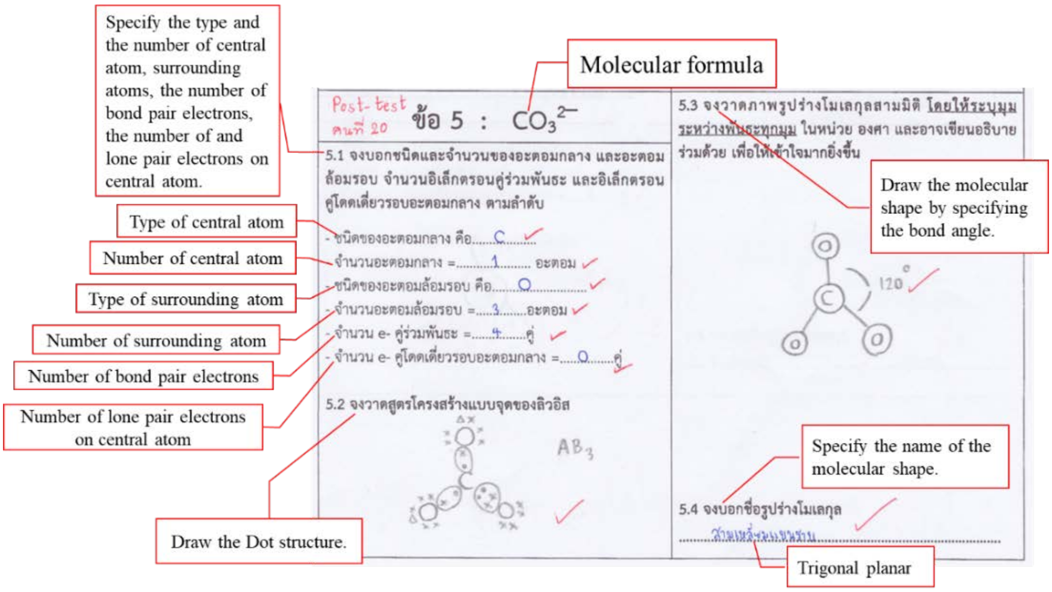

Figure 9: The students' answers of CO_3^{2-} molecule from post-test at the SU level (Student No. 20)

4. The molecular formula of O_3

Before learning, most of the students (69.70%) had a conceptual understanding at the NU level. For example, student number 6's answer (shown in Figure 10) revealed that the student correctly specified an O atom as the central atom and the remaining two O atoms as the surrounding atoms. But the student drew line structures instead of dot structures. This may have led to the incorrect molecular shape drawing and name of the shape.

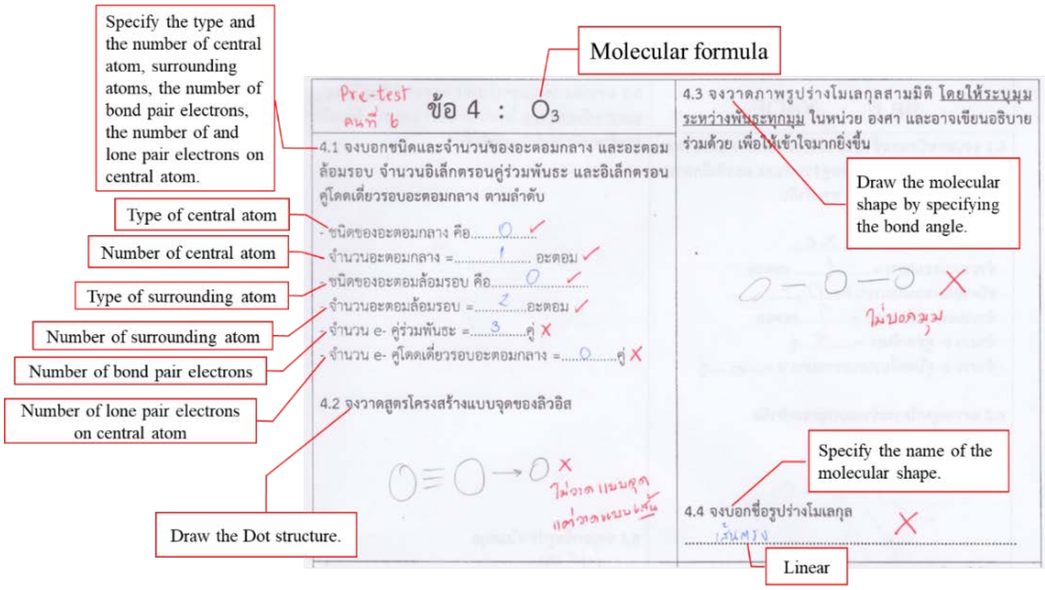

Figure 10: The students' answers of O_3 molecule from pre-test at the NU level (Student No. 6)

After the learning activity, most of the students (42.42%) had a conceptual understanding at the PU level. For example, student number 8's answer (shown in Figure 11) revealed that the student drew the Lewis dot structure with a slight error: the number of valence electrons on O atom as the central atom exceeded eight after sharing in covalent bond. However, the student knew that the O atom as the central atom has one lone pair electron, therefore making it possible to correctly specify the name of the molecular shape as V-shape (or bent) with the bond angle of lower than 120°.

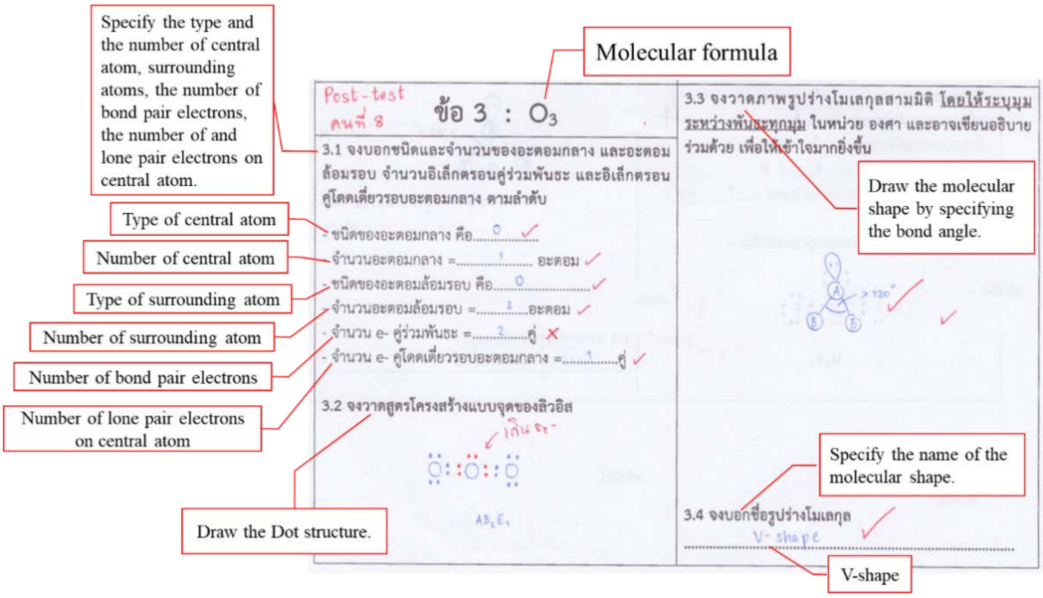

Figure 11: The students' answers of O_3 molecule from post-test at the PU level (Student No. 8)

5. The molecular formula of ClF_3

Before learning, most of the students (57.58%) had a conceptual understanding at the NU level. For example, student number 8's answer (shown in Figure 12) revealed that the student correctly specified a Cl atom as the central atom and three F atoms as the surrounding atoms. Both the number of bond pair electrons (7 pairs) and lone pair electron (7 pair) were incorrectly specified. The Lewis dot structure was improperly drawn due to the Cl atom bonding with three F atoms as the coordinate covalent bond and missing seven valence electrons of all the F atoms. However, the student did not answer the question on the molecular shape and the name of shape.

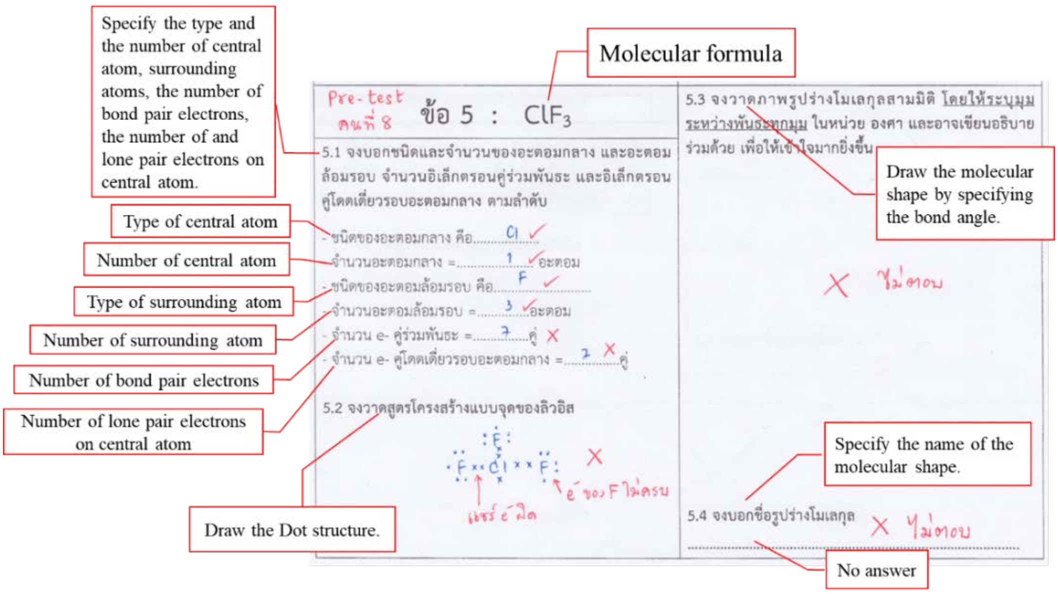

Figure 12: The students' answers of ClF_3 molecule from pre-test at the NU level (Student No. 8)

After learning with the Magnet and Pin kits, most of the students (45.45%) had a conceptual understanding at the SU level. For example, student number 6's answer (shown in Figure 13) revealed that the student could draw the correct Lewis dot structure, leading to correctly specifying those two lone pair electrons on the Cl atom and three bond pair electrons around the Cl atom. The molecular shape drawing, bond angle specifying as lower than 90°, and the name of the shape as T-shape are correct.

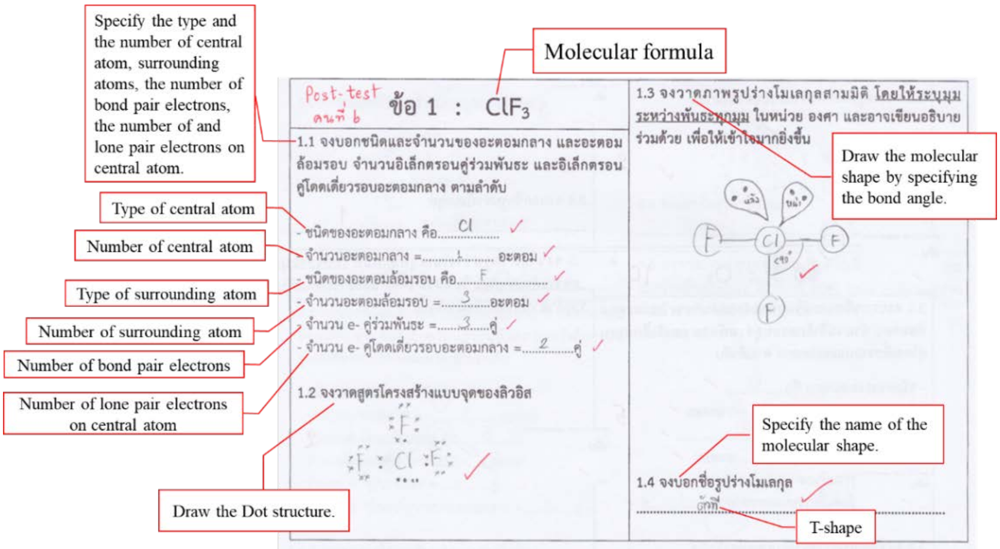

Figure 13: The students' answers of ClF_3 molecule from post-test at the SU level (Student No. 6)

6. The molecular formula of $XeOF_4$

Before learning, most of the students (66.67%) had a conceptual understanding at the NU level. For example, student number 26's answer (shown in Figure 14) revealed that the number of the central atom is two O atoms, the type of surrounding atom is F and Xe atoms, the number of surrounding atoms is 28 atoms, the 5 pairs of bond pair electrons and the 2 pairs of lone pair electron were incorrectly specified. The Lewis dot structure was incorrectly drawn. The molecular shape of $XeOF_4$ was incorrectly drawn and the name of the shape was incorrect.

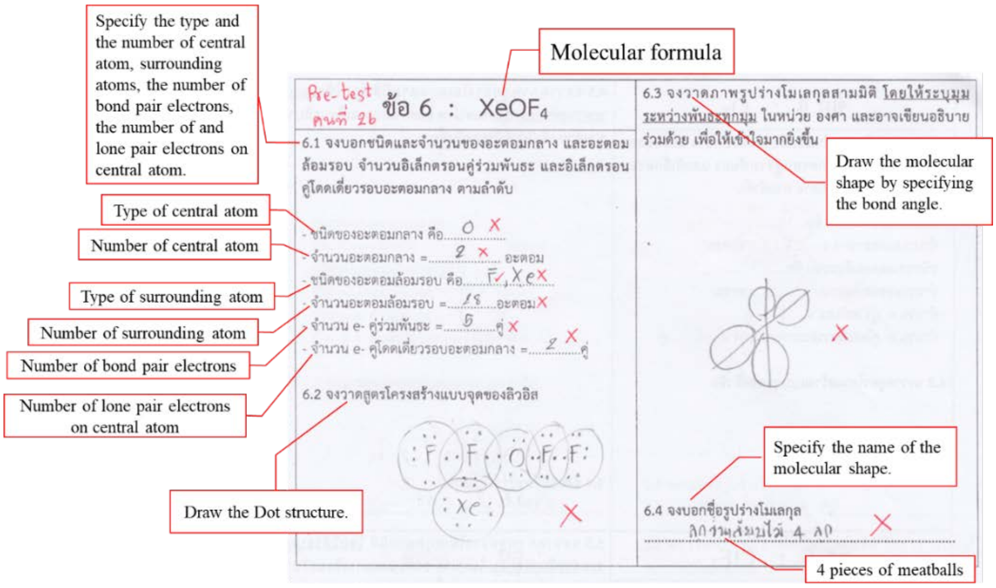

Figure 14: The students' answers of $XeOF_4$ molecule from pre-test at the NU level (Student No. 26)

After learning with the Magnet and Pin kits, the percentages of students at the PU and SU levels are very close (33.33% and 27.27%, respectively). For example, at the PU level, student number 16's answer (shown in Figure 15) revealed that the student could specify the Xe atom as the central atom and five surrounding atoms (O and F atoms). The number of lone pair electrons (1 pair) was correct, but the number of bond pair electrons (4 pairs) was incorrect. The molecular shape drawing and name of the shape as a square pyramid were correct. And the Lewis dot structure was perfectly drawn. While student number 9's answer (shown in Figure 16) was classified at the SU level because the Lewis dot structure was perfectly drawn, and all the answers were correct.

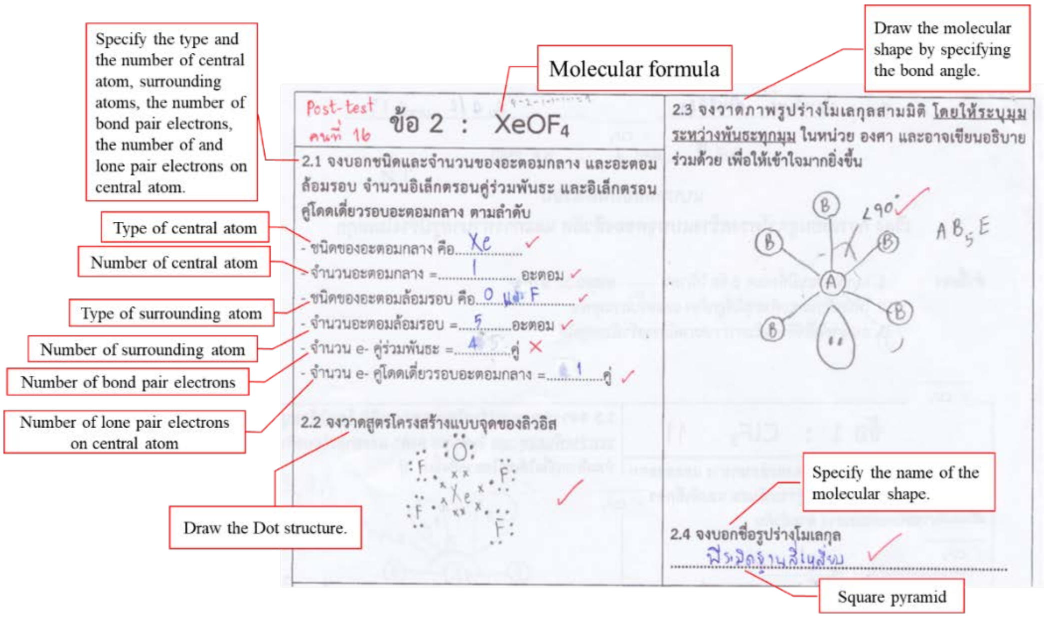

Figure 15: The students' answers of $XeOF_4$ molecule from post-test at the PU level (Student No. 16)

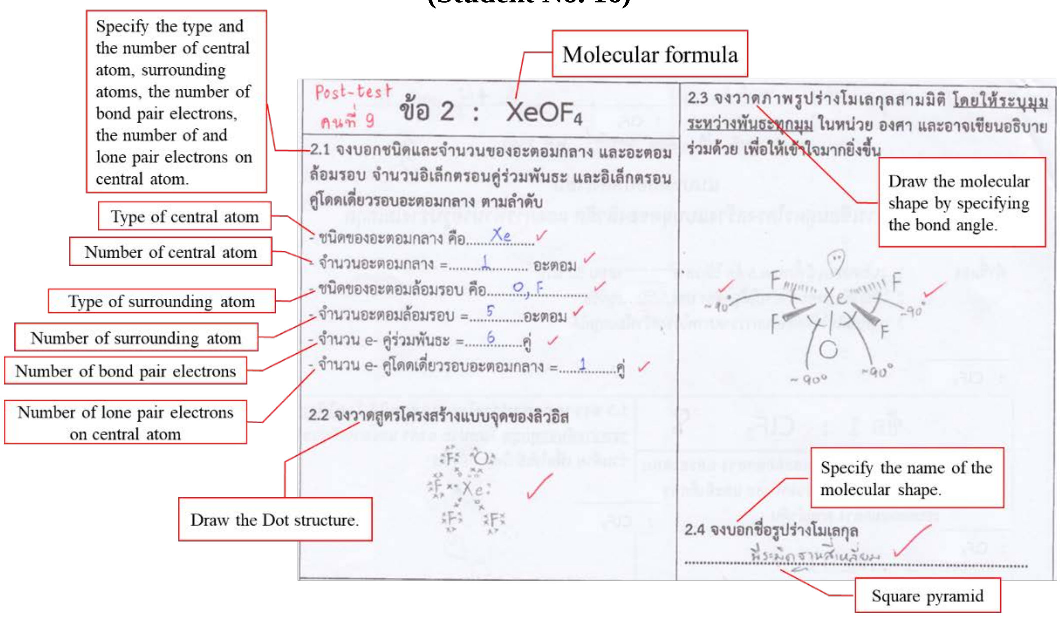

Figure 16: The students' answers of $XeOF_4$ molecule from post-test at the SU level (Student No. 9)

CONCLUSION AND DISCUSSION

The study of grade 10 students' conceptual understanding of Lewis dot structure and molecular shape from learning by using the Magnet and Pin kits found that before the learning activity, most of the students had a conceptual understanding at the NU level of the ClO_4^-, CO_3^{2-} ,O_3, ClF_3, $XeOF_4$ molecular formulas and had SAC level understanding of the PF_5 molecular formula. It showed that the students' conceptual understanding of all molecules was very low. After learning with the Magnet and Pin kits, most of the students' conceptual understanding level increased to the SU level for the PF_5, CO_3^{2-}, ClF_3 and $XeOF_4$ molecular formulas and the PU level for the O_3 and ClO_4^- molecular formulas. This shows that the use of Magnet and Pins kits to learn the drawing of the Lewis dot structure and the molecular shapes prediction can help students increase their understanding to the overall higher level of conception from NU & SAC to SU & PU levels. The students could specify the type and number of central atoms, surrounding atoms, number of bond pair electrons, and lone pair electrons with more than 70% accuracy. The students could also draw the Lewis dot structure correctly and perfectly. There may, however, be a slight misspecification of the number of valence electrons. The students could draw images to represent three-dimensional shapes of molecules and correctly specify the name of molecular shapes. It showed that learning by the Magnet and Pin kits can reduce the number of students at a low level (NU & SAC) of conceptual understanding and increase the number of students at higher levels (SU & PU) of conceptual understanding.

Students used the Magnet kit as a navigational tool that reduces the complexity of drawing a Lewis dot structure before the actual drawing on paper. During this process, the teachers can help validate the correctness of the students' Lewis dot structure. Suggestions may be given by changing the position of the circular magnets instead of erasing the drawings on paper as per the traditional method. The Pin kit was used to create the 3D molecular structures based on the Lewis dot structures using VSEPR theory to predict the molecular shapes. The molecular shapes were constructed by sticking the pins on a spherical eraser with the widest angle. The teachers can help students to validate the molecular shape and give further explanations if they do not understand. In other words, the Magnet and Pin kits are a tool to help check conceptual understanding through conversations between teachers and students. The teacher can use it to examine the student's misconceptions, leading to the possibility of solving problems immediately (Kamkhou and Yuenyong, 2019).

This study showed how the Magnet and Pin kits provided students to learn about dot structure and molecular shape with analogy of Magnet and Pin kits. This could be mentioned that students constructed new knowledge when the intervention is mediated by what they already know (Udomkan et al., 2015; Yuenyong and Thathong, 2015). When dealing with abstract concepts, students require opportunities to create visual representations of these concepts in order to make sense of them (Tan and Yeo, 2022).

Çalik, Ayas, and Coll (2009) argued that a crucial constructivist concept emphasizes the value of learners' prior knowledge while constructing teaching activities or techniques. In other words, the learner attempts to relate new knowledge to what he or she already knows; this serves as the foundation for analogies. It indicates that the Magnet and Pin kits as analogy provides a process of mapping of shared attributes. Analogies operate for this reason, and the learner here is behaving similarly to a scientist (Coll, France, and Taylor, 2005).

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Using Games in Teaching Integrated Science: The Perceptions and Readiness of Teachers

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Abstract. The use of appropriate pedagogy for teaching and learning is very essential for the success of every lesson. Games have been established to be one of the effective methods in teaching and learning at the basic level of education. This study was conducted to find out the perceptions and readiness of integrated science teachers on the use of games in teaching and learning. The investigation targeted the population of the public Junior High School teachers in integrated science at Akyem Oda, the capital of Birim Central Municipal in the Eastern region of Ghana. Thirty-two (32) teachers were assembled through simple random sampling from eleven (11) schools for the study. Questionnaire was used for data collection. Data was analysed descriptively. The findings revealed among the integrated science teachers who previously have used games in teaching and learning as an effective method. However, there was generally a higher negative perception on the use of games in teaching integrated science. Teachers were more inclined to the use of demonstration method in teaching the subject than all other methods. Nonetheless, teachers wish to use games in teaching the subject in the future. There was also a negative correlation between the desire to use games in teaching and learning of integrated science and age of teachers. The findings should guide stakeholders to help strengthen the knowledge base of integrated science teachers in games as its benefits are enormous in teaching and learning.

Keywords: Games, Teachers, Integrated Science, perceptions

INTRODUCTION

Education, whether formal, informal or non-formal is designed to cause expected changes in the cognitive, affective and the psychomotor domains of an individual. Its structures are deliberately weaved to meet the pattern of growth, development and needs of a society, usually at a point in time (Ministry of Education, 2018).

The fundamentals for development and advancement in the world and thus in every country largely hinges on science and technology (Ministry of Education, 2019). It is beneficial, therefore, to every individual to at least acquire some basic general scientific literacy to function effectively and be fit into the current scientific world. It is for this reason that Ghana has chosen the goal "science for all" (Ministry of Education, 2010) and has made the study of science a core subject (mandatory) from the basic level to second cycle to help drive this agenda. In Ghana, science as a subject at the basic school levels is taught in integration. The curriculum consists of topics from biology, physics, chemistry, and agriculture science (Ministry of Education, 2019).

Despite the deliberate effort to achieve the above goal, there are numerous challenges hindering the smooth implementation of this at basic school levels (especially Primary and Junior High Schools) in Ghana. Quality teaching and learning is one of the pillars for imparting scientific concepts in learners (Quansah et al., 2019). Science teachers must provide and ensure quality facilitation (Ministry of Education, 2019) to achieve this. It is, however, unfortunate that methods used by teachers in teaching science has been listed as one of the challenges in science education at the basic levels (Anamuah-Mensah et al., 2017; Fredua-Kwarteng & Ahia, 2005; Ngman-wara 2015; Parker, 2004; Hill et al., 2005). Lecture method which is largely teacher-centered, and imposition of knowledge from the teacher and textbooks on learners has been reported to be the most used in teaching integrated science (Tufail and Mahmood, 2020). This method, like all other teacher-centered methods gives the instructor the convenience in teaching than the learner-centered methods that aid understanding and minimize memorization among learners (The Organization for Economic Co-operation and Development, 2006).

Games as method of teaching has been recommended as one of the effective and child-centered approaches in teaching learners at the basic level (Orim and Ekwueme, 2011; Ziekah, 2014; Yeboah et al., 2023). The following reasons have been assigned to this;

a. Games are used as ice breakers to introduce new concepts, for the consolidation of ideas, for removing drudgery from drill and for creating a positive and enthusiastic atmosphere in classrooms (Orim and Ekwueme, 2011).

b. Games involve well-structured teaching activities with set rules which allow learners to interact with each other and learning resources to reach instructional objectives (Harbor-Peters, 2001).

c. Games help to increase learners' motivation, engagement, and observation skills. It improves collaboration and interaction among learners and enhance their ability to practically apply knowledge gained in teaching and learning in the real world (Hardman & Ntlhoi, 2021; Zirawaga et al., 2017).

All the above support the principles underpinning the implementation of the new science curriculum for basic schools which promotes the use of pedagogies that allow every learner to participate fully in every learning process and enjoy learning (Ministry of Education, 2019). Furthermore, Yeng (2019) reported that games enhance the understanding and output of learners in teaching and learning of science which would result in developing critical thinking and problem-solving skills in the them. However, report on the use of games in teaching integrated science at the Junior High School level in Ghana seem non-existing at time of the study. It is against this background that the study was setup to investigate the perceptions and readiness of integrated science teachers at the public Junior High Schools in Akyem Oda, the capital of the Birim Central Municipality in the Eastern Region of Ghana.

LITERATURE REVIEW

The Impact of Games on the Performance of Learners

The inadequate reliability of the conventional teaching methods in achieving quality education has led to the introduction of several learning models of which incorporating games in the lesson delivery has become a preferred method of choice. Game-based learning in education is mostly perceived as time-consuming method which renders the pupils not serious with learning processes and more so teachers not able to complete their lesson plans. That notwithstanding, if these games are appropriately designed and directed towards delivering curriculum concepts in various subjects or fields of disciplines could play a vital role in providing holistic education (Barzilai & Blau 2014; Qian & Clark, 2016; Chang et al., 2018). A study by Zirawaga et al. (2017) buttress this point by stating that employing games in teaching and learning should be viewed as very instrumental rather than interference since it impacts learners in several ways by introducing, developing and equipping them with skills such as engagement and motivation, visual skills, effective collaboration and interaction with peers. Other skills include problem solving and critical thinking capabilities, creativity, adaptation and sticking to rules or sportsmanship (Ucus, 2015). Pratama and Setyaningrum (2018) conducted a research on the effect of games designed towards problem-solving capabilities that examine learners cognitively and affectively in Indonesia. The findings indicated that leaners who participated in the study improved very well in their learning outcome compared to those who did not. Several studies have reported a direct correlation between game-based learning programs to learner's performance (Bakan and Bakan, 2018). In addition to performance, games are used to complement the learning process to eliminate boredom and stimulate learner's interest to channel their innovative thinking abilities and attention to what is being taught. This promotes effective participation of learners in the learning process as well as enhancing their understanding of concepts (Braghirolli et al., 2016). In the light of limited teaching resources for learning (Quansah et al., 2019) games offer an alternative in terms of engaging learners in the learning process in order to enhance their manipulative skills. Inasmuch as games are considered as an effective tool in the teaching and learning process and more importantly serving as an integral part of instructional pedagogy, Aina (2013) draws attention to the fact that the teacher's preparation towards the lesson which includes the choice of game and its usefulness can influence the effectiveness of the learning process. Some games may possess the requisite potential to instil smartness, logical reasoning and critical thinking into learners but may not contain the examinable instructional content to cause the needed change in the learner. It is very imperative that before games are incorporated in teaching and learning process, teachers would adequately plan ahead stating clearly the objectives, the delivery procedure and items to examine learners in order to ascertain the outcome of the lesson. On the part of learners, the learning process can be very tiring especially at the primary level to the extent that in some cases the learning goals may not be completely achievable. Diana (2010) complained about a noisy and disorganised learning environment when dealing with third grade learners using games which constrained the teacher in respect to time from explaining more to their understanding. However, as already mentioned, it all boils down to the effective planning of the entire teaching and learning process by the teacher. When that is done, a more efficient learning process and orderly controlled environment can be attained as well as achieving the objectives of the lesson.

The Impact of Games on the Learners' Attendance

The trend of research recently in the area of utilizing games in teaching and learning processes is highly encouraged as a result of the level of motivation and interest learners derive which in totality help them to develop the desired behaviour (Ofosu-Ampong, 2020). Learners most often lose interest in learning abstract concepts presented in a monotonous manner through the conventional method of teaching which some researchers describe as poor (Azure, 2015). This to some extent discourages learners from being punctual in school. Once their interest is not sustained in class activities, they tend to resort to other sources of entertainment outside the classroom. Yeboah et al. (2019) reiterate that developing countries such as Ghana lack adequate teaching resources especially in the area of science which requires the demonstration of more practical sessions to stimulate the interest and enhance the comprehension of learners on scientific concepts. The lack of learner's ability to relate with the activities in class already takes the learner out of class even when he/she is present physically. To this end, no meaningful learning take place. Unfortunately, there is rarely published research works that tries to link the use of games in education to learner's attendance. However, it can be deduced so far from the information available the positive impact games would make on learner's attendance as their motivation and satisfaction in the learning process increase. A child who enjoys the learning activities in class will always be present to continue the fun.

Students' Perceptions on Educational Games

It has been reported that games used in teaching and learning aid most learners to have better recall on topics learnt, improve their memorisation abilities, reduces the frequency of revision and enhances knowledge application during assessment. Also, some learners believe that games allow them to revise in comfortable and relaxed mood while being entertained as well. (Cheung, 2021). Others also are of the view that games increase their motivation and activity in learning (Salsabila et al., 2019). Again, learners consider the use of games in teaching and learning as a catalyst which motivate and influence them positively in attitude during lessons compared to the conventional methods of teaching (Ibrahim et al., 2011).

Despite the positive impact of games on learners in teaching and learning, some few learners think they are negatively affected to some extent. Some have testified that games distract their focus and concentration when used in learning. Subsequently, it becomes tough for them in grasping the concepts in lessons (Salsabila et al., 2019). Others think that excessive use of games in teaching and learning results in the neglect of other sources of materials used for learning (Repolusk, 2009).

RESEARCH OBJECTIVES

Generally, the study was setup to investigate perceptions and readiness of integrated science teachers at the public Junior High Schools in Akyem Oda, the capital of the Birim Central Municipality in the Eastern Region of Ghana on games. The was guided by the following specifics;

a) To determine the method most frequently used by teachers in teaching integrated science.

b) To determine the readiness of integrated science teachers to use games in teaching.

c) To determine the perceptions of integrated science teachers on the use of games in teaching integrated science.

d) To establish the correlation between the desire to use games in teaching integrated science and age of teachers.

RESEARCH QUESTIONS

a) What is the method most frequently used by teachers in teaching integrated science?

b) How ready are integrated science teachers to use games in teaching?

c) What are the perceptions of integrated science teachers on the use of games in teaching integrated science?

d) Is there a correlation between the desire to use games in teaching integrated science and age of teachers?

METHODOLOGY

Research Design

Descriptive research design (quantitative) was adopted for this study. It was purposely chosen because its focus is to identify the "what" behind a situation/phenomenon (Manjunatha, 2019) which suited the pursuit of the study to establish the perception and readiness of integrated science teachers towards the use of games in teaching and learning.

Participants Population for the Study

The population for the study consisted of all the thirty-seven (37) integrated science teachers at the public Junior High Schools in Akyem Oda, the capital of the Birim Central Municipal in the Eastern Region of Ghana.

Sampling Techniques and Sample Size

Simple random sampling technique was used to select participants for the research. As a probability sampling technique, it was chosen to ensure a fair representation of all members of the population in the study (Bryman, 2004). Thirty-two (32) Integrated Science teachers were sampled from the total of thirty-seven (37) for the study. This included six (6) females and twenty-six (26) males. Random number table was used to select the participants. In this, each of the thirty-seven (37) Integrated Science teachers was assigned a specific number (from 1-37) in place of their names. The table comprised of ten (10) columns and rows each creating one hundred (100) boxes. Each box had a three-digit number for selection. However, the first two-digits in every three-digit number in a box qualified for selection. Numbers that reoccurred/repeated were only considered once. Selection was initiated randomly by pointing on the first number in the first column without looking on. Upon the selection of the first number, the remaining thirty-one (31) were selected by following the boxes below the column and through other columns from left to right.

Instrumentation and Data Analysis

A questionnaire titled; "Using games in teaching integrated science; the perception and readiness of teachers" was used for the study. Its structure consisted of both open and close-ended questions. Questionnaire as a data collection tool was adopted for its uniqueness and ability to reveal the opinions and determine the future intentions of people (Young, 2016) which rightly suited this study.

The questionnaire composed of four (4) Sections:

a) Section A had the sub-heading, "Demographic information of integrated science teachers". This section was meant for data on age range, gender, number of years in teaching service and number of years in teaching integrated science.
b) Section B had the sub-heading, "Teaching methods mostly used in teaching integrated science". The section specifically was meant to get the most and least used methods by the Integrated Science teachers in teaching.
c) Section C had the sub-heading, "Readiness of Integrated Science teachers to use games in teaching". The section had six (6) questions (both open and close ended) which solicited the readiness of the Integrated Science teachers to use games in teaching.
d) Section D also had the sub-heading, "Perceptions on the use of games in teaching Integrated Science". It consisted of nine (9) statements measured on a five (5) point Likert Scale with the responses;
    1. Strongly disagree (SD)
    2. Disagree (D)
    3. Indifferent (I)
    4. Agree (S) and
    5. Strongly Agree (A)

The data from the study was analysed with IBM statistical package for the social sciences (SPSS) software (version 21.0). Data was generally subjected to descriptive statistics of means, standard deviations, frequencies and percentages. Pearson's correlations analysis was also employed on an aspect of the data.

RESULTS AND DISCUSSION

The result revealed that most of the respondents (62.5%) used the demonstration method of teaching during their integrated science lessons whiles the discovery method (6.3%) and games (6.3%) are the less used methods among respondents (**Table 1**). This indicates that demonstration method seems the most reliable and convenient method for teaching integrated science among respondents. This disagrees with an earlier finding (Otami, 2019). Games and the discovery methods being the least used among respondents could be the respondents' preference for other methods, unsuitability of the methods for teaching integrated science or other hindering factors. It has been reported that teachers scarlessly use games in teaching science since it is an emerging method which the knowledge and significance in teaching and learning is less known especially in the developing world (Marques and Pombo, 2021; Aina**,** 2013). More so, science teachers are often unwilling to use new practices in their teaching (Pombo *et al.*, 2019; Ertmer & Ottenbreit-Leftwich, 2010).

Table 1.: Teaching methods mostly used by respondents for teaching integrated science

Teaching Method	Frequency	Percentage
Lecture	3	9.4
Discussion	5	15.6
Discovery	2	6.3
Demonstration	20	62.5
Games	2	6.3
Total	**32**	**100**

Source: Field data of the study

From the results, 17(53.1%) out of the 32 respondents have previously used a form of game in teaching integrated science (**Table 2**). This describes a situation of fairly good number of respondents with some level of knowledge in games as a method for teaching. Also, it depicts a zeal among the respondents to use or test games for teaching and learning in integrated science. Out of these 17 respondents, 9 (52.9%) recognized it as an effective method for teaching and learning the subject. However, 8 (47.1%) of the respondents believe otherwise (**Table 2**). Though the percentages seemed close, there appear to be a sort of confidence among majority of the respondents in the effectiveness of games in teaching and learning of integrated science. This affirms the stance of other teachers who believe integration of games in teaching and learning have positive influences on the learning process and the outcome (Yeboah *et al*., 2023).

Table 2. Previous use of games in teaching integrated science and its effectiveness

Previous use of games in teaching science			Games as an effective method in teaching science		
Response	Frequency	Percentage	Response	Frequency	Percentage
Yes	17	53.1	Yes	9	52.9
No	15	46.9	No	8	47.1
Total	**32**	**100**	**Total**	**17**	**100**

Source: Field data of the study

The study showed more negative perceptions inclination of respondents towards the use of games in teaching and learning than the positives. Relatively, highest means were recorded for the negatives than the positives perceptions. "Games induces fun rather imparting knowledge", "Games cannot be used to teach practical concepts", and "Games are appropriate for all subjects except science" with the respective corresponding means and standard deviations; (M=3.367; SD=1.0662), (M=3.167; SD= 1.3667) and (M=2.767; SD=1.3047) topped the list of perceptions **(Table 3)**. These could be discouraging factors for the integrated science teachers from using games in teaching and learning. Larbi (2020) and Kubekov *et al.*, (2015) have indicated that frequent use of games in teaching and learning could be distracting through fun, could induce excessive focusness of learners on the events in the games rather than the knowledge and educational significance. Again, the assertion of majority of respondents that "Games cannot be used to teach practical concepts" and "Games are appropriate for all subjects except science" conforms to the reports of Larbi (2020);Gerber &Price (2013) that games are not suitable styles for science teachers to better teach to the understanding of learners. The lowest means recorded for the positive perceptions; "Games promote better recall and application of knowledge", "Games arouse and sustain learners' interest" and "Games ensures better learner-centeredness and involvement" with the respective and corresponding means and standard deviations; (M=1.500; SD=0.9377), (M=1.367; SD=0.6687) , and (M=1.700;SD = 0.9523) proved that respondents acknowledge other teaching methods being better than games in teaching and learning of integrated science **(Table 3)**. This disagrees with an earlier finding (Zirawaga *et al*., 2017).

Table 3. Perception of respondents on the use of games in teaching integrated science

Perception Deviation	N	Mean	Std.
Formulating games is time consuming	32	1.0903	0.9783
Using games in teaching is time consuming	32	2.200	0.9965
Games induces fun rather imparting knowledge	32	3.367	1.0662
It is appropriate for all subjects except science	32	2.767	1.3047
Games cannot be used to teach practical concepts	32	3.167	1.3667
Games enhances understanding of learners than other teaching methods	32	2.233	1.3566
Games ensures better learner-centeredness and involvement	32	1.700	0.9523
Games arouse and sustain learners' interest	32	1.367	0.6687
Games promote better recall and application of knowledge	32	1.500	0.9377

The study, in a way to determine the readiness of respondents to use games in the future for teaching and learning of integrated science revealed that 18 (56.3%) out the 32 respondents would wish to (**Table 4).** This presupposes the existence of conviction among some respondents that games as a method for teaching could enhance the effectiveness and outcome of teaching and learning in integrated science. This has been confirmed in earlier studys (Hwang and Chen 2017; Ezeugwu *et al*., 2016 Boyle; 2011).

Table 4. The desire to use games in teaching integrated science in future.

Response	Frequency	Percentage
Yes	18	56.3
No	14	43.7
Total	**32**	**100**

Source: Field data of the study

A correlation analysis between the desire to use games for teaching integrated science and age of respondents showed a negative and low correlation ($r = -0.058$, $N=32$, $p= 0.76$) between the two variables. This could imply that the desire to use games in teaching and learning of integrated science decreases with increasing in age of respondents. This might be so and high when games are new and more technology based (Charness & Boot, 2009) especially to teachers in developing countries. Therefore, it is likely for younger integrated science teachers to use games in teaching than the older ones. This agrees with the findings of Hamari and Nousiaien (2015).

Table 5. Correlation between the desire to use games in teaching integrated science and age of respondents

		DeGTIS	AoT
DeGTIS	Pearson Correlation	1	-.058**
	Sig. (2-tailed)		.760
	N	32	32
AoT	Pearson Correlation	-.058**	1
	Sig. (2-tailed)	.760	
	N	32	32

Source: Field data of the study; DeGTIS = Desire to use games in teaching integrated science; AoT = Age of Teachers; **Correlation significant at the 0.01 level (2 tailed)

RECOMMENDATIONS

We recommend that further research should be done to cover all the population of integrated science teachers in state owned Junior High Schools within the entire Birim Central Municipal. This will help to expand and consolidate the findings from the study. Again, the knowledge of the teachers in games as a teaching method and their expertise in designing games should also be studied.

CONCLUSION

The study established that most integrated science teachers at the Junior High School level often use demonstration method and less of games in teaching and learning. A few out the teachers who have previously used games in teaching agreed to the fact of it being an effective method of teaching integrated science at the Junior High School level. However, there is a higher wish/readiness among respondents to use games in teaching in the future. The study further determined the existence of a higher negative perceptions on the use of games in teaching integrated science than the positives. It also showed a negative correlation of the desire to use games in teaching and learning of integrated science and age of teachers.

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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: Academic Performance, Modular Distance Learning, Instructional Material Development

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).

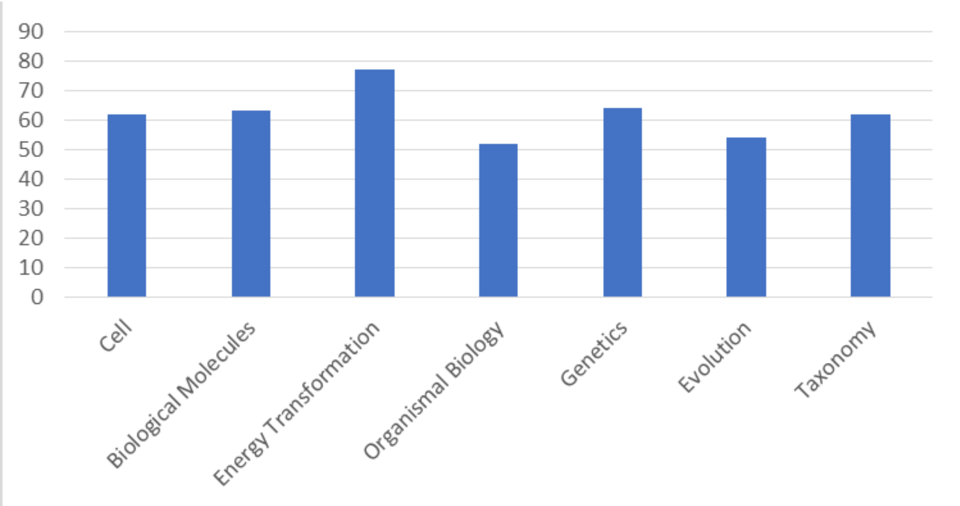

FIGURE 1. *Summary of the Students' Mastery level in Biology in Graphical Representation*

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 Transformatio n	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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Assessing Junior High School Science Teachers' Conceptual Understanding of Force and Motion: Implications for Science Education

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Abstract. This research investigates the prevalence of alternative conceptions regarding Force and Motion among junior high school Physics teachers from public and private schools in Tacloban City, Philippines. The study involved 30 respondents who were selected using the stratified random sampling technique. The Science Teachers Conceptions of Physics Concepts (STCPC) was used as the research instrument, consisting of 30 questions related to Force and Motion with five alternative answers. Descriptive statistics and statistical inference techniques were used to analyze the data collected. Results revealed a high level of misconceptions, particularly in Newton's First Law. Furthermore, there was no significant difference in the level of alternative conceptions across gender. The research recommends using metacognitive strategies to improve teaching skills and promote student-centered learning among junior high school Physics teachers in Tacloban City, Philippines.

Keywords: Alternative conception, Conceptual Understanding, Force, Motion

INTRODUCTION

Correctly understanding scientific and technical subjects requires a sound knowledge of physics, as Bayraktar (2008) stated. Physics is crucial in the junior high school curriculum because it contributes significantly to any society's technological and scientific development. In addition, physics is a prerequisite for studying medicine, engineering, physical sciences, and other related courses in higher education institutions.

Without adequate knowledge and foundation of physics in our society, scientific and technological advancement in the Philippines will be hindered. Therefore, students must develop a solid understanding of physics to promote the development and improvement of science and technology in our society. Omosewo (2008) suggests that to achieve this, physics students must have the correct conceptions of the various scientific concepts they are exposed to in schools and apply this understanding to their daily activities.

By providing a solid foundation in physics, students will be equipped to tackle real-world problems and significantly contribute to our society's scientific and technological advancements. Therefore, it is vital to prioritize the teaching of physics in the junior high school curriculum and ensure that students have a solid grasp of the fundamental concepts of physics. This will contribute to advancing science and technology in our society and provide students with a strong foundation for future academic and professional pursuits.

Over the past decade, students' performance in physics courses has been disappointing, with a clear downward trend (Larkin, 2012). The root cause of this trend has been attributed to students' lack of knowledge of the basic principles, concepts, and laws of physics and their inability to apply this knowledge to solving physics problems, as highlighted by Bani-Salameh's study in 2016. This situation can be attributed to various factors, one of which is students' possession of alternative conceptions, which are inconsistent with scientific views and explanations of physics concepts.

Misconceptions are a significant obstacle to good performance and a thorough understanding of physics. Research on students' understanding of physics concepts has revealed that many students hold misconceptions that impede their understanding of the subject (Hestenes & Halloun, 1995). A significant number of students have been found to have misconceptions about key concepts such as motion and force (Coletta et al., 2007), light (Oktarisa et al., 2017), signals and systems (Larkin, 2012), conservation of principles and fields (Gibb, 2010), and electricity and magnetism (Luangrath et al., 2011), among others.

To improve students' performance in physics, it is essential to identify and address these misconceptions. Teachers should have the knowledge and skills to identify misconceptions and provide appropriate instruction. Furthermore, students should be encouraged to engage in interactive learning activities, such as laboratory experiments, simulations, and discussions, which can help to clarify and reinforce their understanding of physics concepts. Addressing students' misconceptions and promoting active learning can foster a deeper understanding of physics and improve students' performance.

The issue of students' misconceptions in physics is complex. It can be caused by various factors, including interactions with the socio-physical world, textbooks, reference books, language, cultural beliefs, practices, and teachers themselves (Sobel, 2009). However, teachers play a crucial role in addressing students' alternative conceptions because they are students' primary source of knowledge and authority. Formal science instruction is expected to lead to a reduction, modification, or even a change in students' alternative conceptions. Effective teaching should convey accurate scientific knowledge and challenge and correct students' misconceptions (Dergisi, 2010).

According to Haney and McArthur (2002), a child is ready to learn when the teacher is prepared to teach. This means that effective teaching is essential for students to understand physics properly. Therefore, teachers significantly promote students' understanding of scientific concepts by challenging and changing their misconceptions. It is essential that teachers are equipped with the necessary skills and knowledge to teach physics effectively and that they continually evaluate and modify their teaching approaches to address students' misconceptions. By doing so, students can develop a strong foundation in physics and be better prepared for higher education and future careers in science and technology.

In light of the findings of Bektas’s (2015) study, it is crucial for physics teachers to be aware of their students' misconceptions and to have a strong conceptual understanding of the subject matter they are teaching. Without this, teachers may unintentionally reinforce misconceptions or fail to challenge and correct them effectively.

Content knowledge is a crucial component of a teacher's professional expertise. It allows them to make informed decisions about what and how to teach and anticipate and address student misconceptions. However, content knowledge alone is not sufficient for effective teaching. Teachers must also possess pedagogical knowledge, which refers to understanding how to teach the content effectively to students, and knowledge of their student’s cognitive and emotional development (Burgoon et al., 2009). Teachers can create meaningful and engaging learning experiences that foster conceptual change and promote a deep understanding of physics concepts by combining content and pedagogical knowledge.

Teachers play a critical role in helping students overcome misconceptions and learning difficulties in physics. However, this is only possible if teachers have a proper conceptual understanding of the content they teach. Without a solid grasp of the physics concepts, teachers may not be aware of students’ misconceptions and may be unable to facilitate meaningful conceptual change in students.

Studies have shown that some physics teachers lack a sufficient understanding of the concepts they teach, which can lead to a lack of awareness of students’ misconceptions (Omosewo, 2008). This can result in ineffective teaching, affecting students' learning outcomes. Therefore, it is essential to investigate teachers' conceptual understanding of physics concepts to identify areas of weakness and to improve teacher efficacy in the classroom.

One way to improve teacher efficacy is by focusing on improving their conceptual understanding of specific physics concepts, such as motion and force. These concepts are widely taught in schools and are prone to alternative conceptions among students (Fatokun, 2016). By understanding these concepts thoroughly, teachers can identify students' alternative conceptions and facilitate meaningful conceptual change.

It is essential to note that teachers serve as a source of influence for knowledge students. Therefore, any effort to correct misconceptions in students should start with improving the teacher's conceptual understanding of the subject matter. This is because the conceptual understanding of the teacher must improve before any meaningful improvement can be expected in students' learning and understanding of physics concepts.

This study investigates junior high school science teachers' conceptual understanding of motion and force. The findings of this study could help identify areas of weakness and provide insights into improving teacher efficacy in the classroom. Doing so will contribute to improving students' learning outcomes in physics.

Kruger, Palacio & Summers (1992) conducted a study investigating British primary school teachers' understanding of the force. The study found that many teachers were uncertain about what could be considered a force, particularly regarding reaction force, friction, and weight. About 40% of the teachers were unsure whether weight could be considered a force, and more than half were unaware that weight is a gravitational force. Additionally, many teachers had difficulty finding resultant force via vector addition. Responses to questions related to dynamic situations revealed that primary school teachers' conceptions of force and motion were not Newtonian. Furthermore, as many as 91% of the teachers believed in naïve impetus theory, and many could not differentiate between momentum and force.

In the Philippines, research on the understanding of science concepts has mainly focused on student misconceptions in high school and college, with little empirical work done on teachers' understanding. One such limited study was conducted by Demirci (2008), which only considered teachers from public secondary schools and the effect of qualification on their understanding. This study aims to include teachers from private and public junior high schools to ensure the external validity of the results, as student performance in physics is reported for both types of schools. Additionally, this study will examine the influence of teaching experience, specialization, and qualification on the conceptual knowledge of physics teachers in the selected concepts. By providing current data on the understanding of motion and force concepts among teaching staff, this research will contribute to understanding high school physics education in the Philippines. Furthermore, this study will compare results with studies on the same topic in other countries to determine whether cultural differences affect high school teachers' alternative conceptions.

Over the years, student performances in external physics examinations have been consistently poor, possibly due to their misconceptions of essential physics concepts. Studies have shown that these misconceptions hinder students' understanding of the subject and negatively affect their performance. It is widely believed that teachers' conceptual knowledge of their teaching topics can lead to better student outcomes. However, several studies have shown that students still possess alternative conceptions of science concepts, even after being taught in secondary schools. This highlights the need to investigate teachers' conceptual understanding of physics concepts.

In the Philippines, most studies on science concepts have focused on student misconceptions at the high school and college levels, with little empirical research on teachers' understanding. This research addresses this gap by investigating misconceptions and alternative conceptions of Force and Motion among junior high school teachers, considering both gender and school type (public and private).

The research questions are: (a) What is the level of alternative conceptions of Force and Motion among junior high school teachers? (b) Is there a significant difference in the level of alternative conceptions of Force and Motion among junior high school teachers across gender?

This study is essential as it significantly impacts curriculum development and student achievement. Furthermore, this study aims to pave the way for further research on teachers' conceptions of science, which is crucial in ensuring better student outcomes. By identifying and addressing teachers' alternative conceptions, it may be possible to improve student performance in physics.

METHODOLOGY

The research design used in this study was a Survey research design, which involved providing a two-tier diagnostic test instrument to junior high school science teachers to gather information about their conceptual understanding of the concepts under study. The focus population of the study was all science teachers teaching physics in public and private junior high schools in Tacloban City Division. The researchers used a stratified random sampling technique to select 30 teachers from the target population, ensuring that each subgroup was adequately sampled and represented.

A two-tier diagnostic instrument for assessing Science Teachers' Conceptions of Physics Concepts (STCPC) was used to achieve the study's objective. The STCPC consisted of two parts, with 20 multiple-choice questions and a reliability score of 0.77. The questions were divided into five Newtonian concepts. The instrument was validated by two Physics teachers in junior high schools and college, a professor in the science department of teacher education at the University of Tacloban City, and an expert in measurement and evaluation.

The researchers modified the two-tier diagnostic instrument Fatokun (2016) to obtain relevant information from the teachers to suit this study, including demographic profiles and an opportunity for teachers to explain their options. The instrument was designed to elicit the correct conception or alternative conceptions held by the participants.

The data collected were analyzed using SPSS software, with descriptive statistics presented in mean, standard deviation, and percentage. The researchers also used a t-test to determine whether there were any differences among Physics junior high school teachers on the subtopic of Force across gender. Finally, the percentage of misconception for every subtopic of the Newtonian concept was obtained by dividing the marks of the incorrect answers with the total scores of each subtopic and compared to the Alternative Conception Division Level Table.

Overall, the study's research design, instrument, and sampling technique were well-planned and implemented, allowing the researchers to gather relevant information about junior high school science teachers' conceptual understanding of the concepts under study. The study's findings may have implications for science teacher training and professional development, and further research in this area is warranted.

Table 1. Alternative Conceptions Division Level Table

Percentage	Level of Alternative Conception
85 - 100	Very High
70 - 84	High
55 - 69	Moderate
40 - 54	Low
0 -39	Very Low

To administer the STCPC instrument, the researchers followed a series of steps. The initial step involved seeking permission to conduct the research and scheduling a meeting with 30 teacher respondents. During this meeting, the researchers gave instructions on completing the inventory, stressing the need to keep the questions confidential. Once the respondents received the inventory, it was later collected, and each respondent was presented with a token of appreciation as a souvenir.

The process of marking the inventory was conducted over three weeks, from week three to week five. The data collected were entered into the Statistical Package for Social Science (SPSS) software the following week. The data were analyzed and presented descriptively, using percentages, mean, and standard deviations to provide a comprehensive overview of the findings. Finally, in week eight, the inventory results were fully reported, highlighting the study's alternative conceptions held by junior high school teachers.

RESULTS AND DISCUSSION

This study’s results highlight several misconceptions junior high school teachers held about the subtopic of Force and Motion. Table 2 shows that the overall level of alternative conception among the respondents was high (74.39%). The subtopics with the highest levels of alternative conception were First Law (86.19%), Superposition (83.33%), and Kinematics (80.56%). The subtopics with moderate levels of alternative conception were the Second Law (65.00%), Forces of Fluid Contact (65.00%), and Third Law (69.17%). Of these subtopics, the highest percentage of alternative conceptions were found about Newton’s First Law. Many respondents were uncertain about the definition and held a common misconception that “if no net force acts on an object, the object must be at rest.” This misconception is related to the impetus theory, which describes a force that acts on an object, giving it a momentum that keeps it moving even when no force is in contact with it. Fifth-century philosopher Philoponus introduced this idea to explain projectile motion, which is incompatible with Newton’s First Law.

Table 2. The Level of Alternative Conception among junior High School Teachers on The Subtopic of Force and Motion.

Concept	Mean	Standard Deviation	Percentage (%)	Level of Alternative Conception
1. Kinematics: Discrimination of position, velocity, and acceleration Constant acceleration Vector addition of velocities	4.83	0.95	80.56	High
2. Newton's First Law: With no force With canceling forces	6.03	1.3	86.19	Very High
3. Newton's Second Law: Impulse force Constant force implies constant acceleration	2.6	1.22	65	Moderate
4. Newton's Third Law: For impulse force For continuous force	2.77	0.68	69.17	Moderate
5. Superposition: For impulse force For continuous force	2.5	0.86	83.33	High
6. Kinds of Force:				
Solid contact: passive, impulse, friction opposing motion	3.03	0.89	75.83	High
Fluid contact: air resistance, buoyant	1.3	0.65	65	Moderate
Gravitation: acceleration independent of weight Parabolic trajectory	7	1.29	70	High
Total	**30.06**	**7.84**	**74.39**	**High**

Another subtopic with high levels of misconception was Superposition. Respondents were confused about the action/reaction pair with the Superposition of oppositely directed forces on a single object. This highlights the need for teachers to help their students understand the difference between these concepts. In the subtopic of Kinematics, respondents had high levels of misconception regarding the three vital concepts of position, velocity, and acceleration. The Science Teachers' Conceptions of Physics Concepts successfully reflected the ability of junior high school teachers to recognize the vectorial nature of velocity and acceleration. However, the high level of misconceptions in this subtopic suggests that there is still room for improvement.

Other studies using the STCPC have shown similar findings, with high levels of misconception among pre-service teachers in Turkey (Bayraktar, 2008) and British primary school teachers (Kruger, Palacio, & Summers, 1992). T-test analysis (Table 3) showed no significant mean difference between male and female respondents in the level of misconceptions, suggesting that both genders have similarly high levels of misconceptions.

This study highlights the importance of addressing misconceptions about Force and Motion among junior high school teachers. These misconceptions can significantly impact students' understanding of physics concepts, so teachers must be aware of them and address them in the classroom.

Table 3. The Alternative Conception among Junior High School Teachers on The Subtopic of Force and Motion.

Alternative Conception	N	Mean	Standard Deviation	df	t	Sig.
Male	9		4.77			
Female	21	21.667	3.192	28	-0.29	0.468

Based on the research findings, there was no significant difference between male and female respondents regarding the level of misconception at the significant level of 0.05. Although there is a slightly different mean between male and female respondents, with males having a mean of 21.667 and females having a mean of 22.095, the level of alternative conceptions between both genders is still high.

A previous research study conducted by Temizkan (2003), titled 'Effect of Gender on Different Categories of Students' Misconceptions about Force and Motion,' also found no significant difference in the level of misconception between male and female respondents. The study involved 651 high school students from 20 different high schools in the Middle East. However, the mean value for male respondents was much higher than that of female respondents, with 9.73 and 37.85, respectively.

Both research studies show slight differences in mean values between male and female respondents, with one gender having a higher mean than the other. The findings of Derya Temizkan's study suggest that male students had more experience with force and motion than female students, possibly due to gender bias in the Middle Eastern education system. This gender bias has been highlighted in previous reports, such as the AAUW Report: How Schools Shortchange Girls (Wellesley College Center for Research on Women, 1992), which showed that girls were not receiving the same quality or quantity of education as boys.

It is important to note that the culture and education system in Asian countries may differ from those in the Middle East and the Western world. Therefore, female respondents with a higher mean than male respondents in this study may be acceptable.

CONCLUSION

In this study, the researcher examined the level of understanding of junior high school teachers on the physics concepts of Force and Motion, focusing on gender differences. The study concluded that junior high school teachers understand the concept of Force and Motion, and there was no significant difference between male and female teachers.

To further improve the understanding of physics concepts among junior high school teachers, it is recommended to apply a teaching approach that emphasizes conceptual understanding. This approach can help to address the issue of alternative conceptions, which can lead to misconceptions among students.

Özdemir, E. (2010) suggests that teachers should use various teaching styles and situations to help students apply the concepts they have learned and provide explanations for their answers. Teachers can help students develop an honest and accurate understanding of physics concepts using a more comprehensive teaching approach.

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Teacher Representations of Pedagogical Content Knowledge (PCK) in Biology Classroom

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Abstract. This is qualitative-quantitative research, where the main concern is to investigate pedagogical content knowledge representation of Biology Teachers and determine the effect and/or subsequent relationships with the student conceptual understanding. The study focuses on six biology teachers and a total of 222 students in their respective classes. The study utilizes classroom discourses analysis, interpretative case study method, bracketing method, and concept analysis for the qualitative part; the quantitative part uses a non-parametric statistical tool, Kendall's Tau Coefficient test on the relationship of Teacher's representation and students' conceptual understanding, and paired t-test for differences of pre- and post-instruction of concepts. The data collection entailed seven (7) months immersion: one month for preliminary phase for the researcher to gain teachers' and students' confidence and the succeeding six (6) months for the main observation and data collection for the research. The study reveals some patterns of teachers' activities inside a biology classroom, particularly in planning the lesson, motivation, assessing students, teachers' schema in representing content knowledge (Declarative and Procedural) inside the biology classroom. The effects and/or relationships of teachers' representation to students' conceptual understanding indicated that teachers' representation of content knowledge does affect the individual students' conceptual understanding by increasing complexity of their knowledge structure as well as spread of scores in the class.

Keywords: Teachers' representation, Pedagogical Content Knowledge, Philippine Setting

INTRODUCTION

The instructional ability of teachers inside the classroom plays a significant role in the teaching process. Evidence, which indicates the teachers' representation of content knowledge has a positive influence on classroom instructions, is available (Thorley and Stofflet, 1996). However, it is common knowledge in the academy that there are teachers who are equipped with content knowledge but are unable to translate their ideas into representations that can be understood by students. The translation of science into representations understandable in students distinguishes a science teacher from a scientist. Wineburg and Wilson (1991) stated that:

> *…their aim is not to create new knowledge in the discipline but to create understanding in the minds of the learners. Unlike the historian, who only has to face inward toward the discipline, The teacher of history must face inward and onward, being atone deeply familiar with the content of the discipline while never forgetting that the goal of this understanding while never…. forgetting that the goal of this understanding is to foster it in others…. it is precisely in the meeting of subject matter and pedagogy... that we see the expertise of…teachers most clearly (pp. 335-336)*

If this claim is resolved. Then teachers in any field be able to promote students' conceptual understanding.

Previous studies have pointed out that students are not capable of having Conceptual change as a result of teacher instruction. However, old theories that emphasize the incapacity of the students to facilitate conceptual change of biology concepts are nowadays being questioned (Abd-el-Khalik and BouJaoude (1997).

Teachers whose knowledge is more implicit, coherent and integrated, tend to teach the subject more dynamically, represent it in more varied ways, and encourage and respond fully to students' comments and questions. But when knowledge is limited, the tend to depend on the text for content, de-emphasize interactive discourses in the form of seat work assignment and, in general, portray the subject as collection of static and factual knowledge (Brophy, 1991). in this contention, meaningful understanding of the concepts in biology depends on teacher delivery of their subject matter to students. Learning to be meaningful, requires understanding of concepts and acquiring new meaning after formulation of non-arbitrary and verbatim relationship among ideas in the existing relevant aspect of the learner's cognitive structure (Carvallo and Shaper, 1994).

If teachers are incapable of representing content knowledge, they cannot help in their students desired learning. If teachers can represent well the concept to students, it is possible that students as well can represent their ideas based on teacher's representation. In this aspect, the student representation of knowledge can be captured through the help of writing. Fellows (1994) asserted that student's writing is a potential source of representation of their ideas, which changes during science lessons.

In Iligan city and Lanao del Norte in the Philippines result of National Achievement Test (NAT) and National Career Assessment Examination (NCAE) is very frustrating; students found to have very low performance in areas of Science, Mathematics and English. In this study, the researcher try to look into the problem in lens of a teacher as instructional developer of knowledge by looking into their representation of Pedagogical Content knowledge inside the classroom. Representation of content knowledge in this study refers to how the teachers present their ideas of the topic inside a biology classroom and on how skillful they are in attaining knowledge attainment among students in presenting their declarative and procedural knowledge. Theoretically, this study assumes the idea of constructivism where the theory that says learners construct knowledge rather than just passively take in information. As people experience the world and reflect upon those experiences, they build their own representations and incorporate new information into their pre-existing knowledge (schema). This means that if the teacher is able to represent his/her ideas both content and methods to the students, it reciprocates that the students can apply what the teacher teaches and learn from him/her.

This is a qualitative-quantitative research, where the main concern is to investigate pedagogical content knowledge representation of Biology Teachers and determine the effect and/or subsequent relationships with the student conceptual understanding.

METHODOLOGY

The subject of the study was three (2) junior and two (2) senior high biology teachers in the Department of Education, one (1) private high school and one (1) biology teacher in State University Laboratory School. A total of six (6) respondents were used in this study. This purposive sampling was done to facilitate representation of different school types in the area of concern.

There were five biology topics studied in this research. These include the following: (1) Cellular Respiration; (2) Photosynthesis; (3) Human Reproduction; (4) Mendelian genetics; and (5) Non-Mendelian Genetics. The selection was based on the following: (1) the topics are easily integrated and conceptualized using concept maps; and (2) the topics are slightly difficult to teach because the teacher has to have some in-depth knowledge about the topic. The study utilized classroom discourses in these five biology topics during classroom observation among biology teachers. A total of 30 classroom discourses, five (5) discourses were analyzed per topic. Teacher's pedagogy was analyzed using a five-point checklist developed by Ravina (2001) which was validated for consistency and reliability during her study. Motivational Activities were analyzed using classroom discourses dialogue between the students and teacher in the 30 discourses. Assessment for learning, assessment of learning and assessment as learning were inspected in the dialogue between the teacher and students in the discourse and were categorized if it assesses higher order thinking skills of not. It also scrutinized the manner of how the question is asked, wait time and tools used during classroom discourses. Representation of Content knowledge in this study refers to how the teacher showed their expertise in the biology topic in presenting their ideas about the topic. For example, how he/she explains and presents the declarative and procedural content knowledge in genetics. These were measured by analyzing classroom discourses by looking into how the teacher represents his expertise of the topics. The study looks into declarative knowledge by how the teacher bring the concepts of the topic in their classroom through different methods of teaching while procedural knowledge was scrutinized during the conduct of their laboratory and other solving problem activities. Moreover, the researcher utilized experts (say, a PhD in genetics inspect the correctness of content knowledge of teachers based on the classroom discourses transcripts) to look into correctness of the concepts on biology. Also, the researcher examined the definition, the defining attributes, the example and non-example, the taxonomy of the concept, the statement of principles and the vocabulary provided by the teacher during classroom discourses. Likewise, the four successive levels of concept attainment suggested by Klausmeier (1974) are determined based on the criteria shown in Table 1.

Qualitative data using classroom discourses were utilized to describe patterns of teacher's activity inside the classroom. These are determined by identifying and describing the patterns in classroom discourses of the topics mentioned. Observed patterns are on classroom pedagogy, motivational skills, assessing skills and content representation of Biology topics. Moreover, Quantitative data utilized in this study are the scored concept maps made by both teachers and students to determine congruence of knowledge representation of teachers and conceptual understanding of students using maps scored by structural and relational scoring used by Barquilla (2018). Coding of data with the use of three combination letters was used to hide the identity of the respondents being part of ethical consideration.

Table 1. Patterns of Students-Teacher Interaction inside Biology Classroom

Level of Concept Attainment	Description
Concrete Level	• Attending perceptible features of thing, object or event. • Discriminating the thing, object or event from other things, objects or events. • Remembering the discriminated thing, object or event
Identity Level	• (Concrete level above) plus: • Generating that two or more forms of things are the same object.
Classificatory Level	• (Concrete level) • (Identity level) plus: • Generalizing that two or more example are equivalent and belong to the same class of thing.
Formal Level	• (Concrete level) • (Identity level) • Classificatory level) plus: • Discriminating Attribute of the class • Hypothesizing relevant attribute and/or rules, remembering hypothesis and evaluating the hypothesis using positive and negative instances. • Cognizing the common attributes and/or rules in positive instances. • Inferring the concepts

RESULTS AND DISCUSSIONS

Biology Teachers' Pedagogy

The pedagogy of teachers inside the classroom is determined with the use of an observation checklist and classroom discourses. For instance, the teachers' pedagogy was determined using a five-point scale checklist where 1 is the lowest and 5 is the highest as illustrated Table 2.

Table 2. Description of Pedagogy Used by Biology Teachers in Classroom discourses.

Scale	Description*	Percentage of Pedagogy used by Biology Teacher (n=30 discourses)
1	Pure one-way pedagogy (The teacher makes no attempt to monitor students learning through oral questioning)	0
2	Predominantly one-way pedagogy (the teacher accept choral answer to questions)	0
3	Initial step towards two-way pedagogy (The teacher directs some questions to individual students, but does not use their responses formatively in the discussion.)	(13) 43%
4	Incomplete two-way pedagogy (The teacher directs many or most questions top individual students, occasionally uses those responses formatively.)	(16)53%
5	Full two-way pedagogy (There is effective dialogue between teacher and students in construction of knowledge and concepts.)	(1)4%

*Ravina (2001)

Table 3 presents the pattern of teacher's type of pedagogy used inside the classroom. Of the 30 classroom discourses, 16 (53%) incompletely two-way pedagogy, meaning, the teacher directs many or most questions to individual student but occasionally uses those responses formatively. On the other hand, 13 (43%) have initial step towards a two-way (I.e., biology teachers direct some questions to students but do not use students' responses formatively in the discussion. While only one or 4% utilize a full two-way pedagogy. This implies that biology teachers lack an effective dialogue between them and their students in the construction of knowledge and concepts.

Table 3. Patterns of Students-Teacher Interaction inside Biology Classroom

Type of Teacher-Student Interaction	Frequency	Percentage (%)	Qualitative Description
Teacher-dominated	29	97	Mostly teacher talks/activities
Student-dominated	0	0	Mostly Student talks/activities
Teacher-Student Dialogue	1	3	Equal proportion of teacher and student talks/activities
Total	**30**	**100**	

Furthermore, the types of classroom interaction inside the biology classroom are shown in Table 2. Once again, teacher-student interaction is based on classroom discourse. Cross-validated by an observation checklist. Student-teacher interaction is determined and classified based on the ratio of student and teacher activities/talk inside the classroom. Results reveal that 97% of the discourses are teacher dominated. There are more teachers talk or activities rather than student activities.

This result suggests that biology teachers' type of pedagogy reflects the intention inside biology classrooms. The incomplete two-way pedagogy does not promote good interaction between students and teachers. Teachers tend to dominate the activities, which does not facilitate good dialogue between the learner and speaker and, as a consequence, does not develop and promote teacher's pedagogy can be generally stated as teacher-dominated and incomplete two-way pedagogy.

Biology Motivational Activities

Teachers' motivational activities can be done any time within the class period. Based on the data gathered, all the teachers provide initial motivation to students prior to the introduction of the topical conception.

Table 3 summarizes the opening motivational activities and skills to the five topics observed from the six teachers. It can be said that the teachers use various methods of initial motivational activities to stimulate students' interest in the topic. For example, an opening motivational activity used by Teacher FTC in Discussing the topic photosynthesis started with the history and Philosophy of science to interest the students on the development of a scientific invention. On the other hand, the use of visual demonstration and asking questions about the topic to stimulate students' visual activity (to stimulate/ignite thinking skills through analytical thinking about the diagram) are among the initial strategies used by other biology teacher. Such strategies were used by Teacher RTL, JTB and JTM. While others used previous knowledge as springboard for introducing the new topic.

Moreover, Table 4 presents the motivational skill and strategies utilized by the biology teachers during the opening of the class discussion. Teacher JTM for instance, conducts a laboratory activity to facilitate the discussion in Photosynthesis. Science Teachers are, in fact, expected to be knowledgeable about this technique as well as the content knowledge to be able to discuss the results of the laboratory activity and connect the main idea to the main topic.

Biology teachers use different strategies depending on the topic and the appropriateness of the strategies.

Generally, biology teachers utilize different opening motivational strategies. To summarize, these strategies are: (1) reviewing the previous lessons and relating to the present topic (40%); (2) starting with definition and elaborating it (14%); (3) using an actual example (14%); (4) using an illustration (10%); (5) using a passage in a textbook related to the topic (6%); (6)using laboratory activities and relating them the present topic (3%); and (7) using PROBEX (predict-observe-explain) technique to ignite the students' interest (3%).

Meanwhile, about 50% of the teachers use the following motivational strategies in their classroom planning more activities that cater to students' interest and requiring students to relate the previous topic with new topic.

About 30% utilize the following motivational activities: providing encouragement to students with low performance, offering rewards as incentives for performing well; structuring appropriate and healthy competition, giving more opportunities for student to participate, applying novel and interactive instructional method, asking questions related to the assignment, and reviewing the previous lesson and relating it to the new lesson.

About 10% use history and philosophy of science in stimulating interest in the topic.

In general, the clinical interview, lesson plan, classroom discourse transcripts and observation show that the teachers follow a logical sequence in putting motivation and strategies in their lesson. The motivational strategies start even before the lesson implementation. For instance, teacher FTC and CTC identify the objectives for the lesson and provide meaningful learning activities based on the identifies objectives. From there, they select the appropriate opening stimulating activities relevant to the lesson. Considering the learning objectives and the importance of the topic to everyday life, they prepare instructional materials so that the lesson (especially if it involves abstract concepts) becomes concrete to the students. The motivational strategies used by all the teachers are as follows: (1) identifying meaningful learning objectives for the topic; (2) Starting stimulating activities relevant to the lesson; (3) Pointing out the importance of the lesson in daily activities; (4) Providing students with concrete instructional support; and (5) Presenting abstract concept concepts concretely in a more personal and familiar manner.

Meanwhile, other motivational activities used by some teacher are: planning more activities that cater to students' interests and requiring student to relate the previous topic with the new topic, providing encouragement to low performers, offering rewards as incentives to performing well, encouraging appropriate and healthy competition, giving more opportunities for the students to participate, applying novel and interactive instructional methods, asking questions related to the assignment, reviewing the previous lesson and relating it to the new lesson, and using history and philosophy of science in stimulating student interest on the topic.

Biology teachers' Assessment

Teacher assessment of students' learning can be in the form of questions evaluating students' understanding. This can be done after the class discussion or during the learning process itself. In this study, questions of teacher while developing conception were counted, evaluated, and classified based on the type of questions.

There were 628 assessment questions identified from thirty classroom discourses. Assessment questions were classified according to whether the question requires higher order thinking or simple recalling. Results in Table 5 show that about 50% of the questions qualify as higher-order thinking questions. These are distributed into critical thinking questions which analyses arguments (23%), problem solving which analyze alternative solutions (17%), decision-making questions which pertain to making a choice from a number of options (12%) and creative thinking question (0.48%). However, it is apparent in the data of the five types of questions, that majority are simple recall (48%).

Table 4 further classifies questions as to whether these are divergent or convergent. A convergent is one that requires one exact answer, while divergent question requires varied answer. Of the 628 questions asked by the teacher in the process of teaching, there were 267 (58.4%) convergent questions, and 261 (41%) divergent questions.

Table 4. Distribution and Classification of Assessment Questions Generated by Biology Teachers during Classroom Discourses

Types of Assessment Questions	**TOPIC**						
	P	**CR**	**HRS**	**MG**	**NMG**	**f**	**%**
Problem Solving	0	12	0	44	50	106	**16.90**
Creative Thinking	0	3	0	0	0	3	**0.48**
Analytical thinking	24	7	16	20	6	73	**11.62**
Critical Thinking	25	40	35	13	31	144	**22.92**
Simple Recall	76	72	67	46	41	302	**48.08**
Total	**125**	**134**	**118**	**123**	**128**	**628**	**100**

In addition, Table 5 provides the data on the teachers' manner of questioning. As revealed in the Table, sixty percent are specific questions to a particular concept discussed in class. In 53% of the questions, the teacher gave time for students to think before responding. The wait time ranged from 2 to 40 seconds depending on the kind of questions. Generally, however, the average is about 12 seconds. A 12 second wait time is necessary to allow students, especially a slow learner, to organize his/her thoughts. In most cases, whenever a student cannot answer the question, the teacher usually repeats it or rewords it or asks leading questions. This implies that that teachers provide enough chance for the student to answer correctly. However, this is not done as often as desired, the frequency of phrasing or rephrasing clearly in Table 5 is only 53%.

Meanwhile, some of the teachers asked questions that encouraged participation of students (3.18%).

Table 5. Manner of Questioning of Biology Teachers during Classroom Discourses in Five Biology Topics

Manner of Questioning	**Frequency**	**Percentage**
1. Phrases and rephrases the question clearly	335	**53.3**
2. Asks specific questions	377	**60.0**
3. Give the Students to think before responding. Average wait-time: 11.8 seconds (Range: 2-40 seconds)	334	**53.1**
4. Ask questions that encourage students' participation (N=626)	20	**3.18**
5. Encourages Students to ask question and answer them	17	**15.7**
6. Asks convergent questions (N=628)	367	**58.4**
7. Asks divergent questions (N=628)	261	**41.6**

As shown in the sample questions, the teacher tries to encourage the students to participate in the classroom discussions. However, it is sad to note that only about 17% out of 108 (15.7%) teachers encourage students to ask questions and answer them. This low percentage means that teachers did not sufficiently encourage two-way communication during discussion.

Table 5. Assessment Tool used by Biology Teachers

Tool Used	Frequency	Percentage (%)	Rank
Pencil and Paper testing	14	47	**1**
Rating Students' class participation	0	0	**6**
Giving homework/Assignment	0	0	**6**
Student-teacher conference	0	0	**6**
Asking questions during class discussion as sort of evaluation	8	37	**2**
Oral testing after the lesson has been presented	3	10	**4**
Essay Writing	5	16	**3**

Table 5 gives a ranking of assessment tools based on frequency of use by Biology teachers. As shown, forty seven percent use traditional pencil-pen testing, which ranks first. This result suggests that the teachers still rely on the traditional method of assessment. Thus, they need to attend in-service training to learn more modern techniques in students' evaluation and assessment such as portfolio assessment, concept mapping, and other authentic assessment tools.

Biology Teachers' Representation of Declarative and Procedural Knowledge

Looking into how the biology teachers represent concepts inside the classroom provides insight for in-service teacher training of biology teachers to improve teaching and learning. Declarative knowledge of biology teachers is based on their proposition, imagery, and linear ordering as they together form their representation into a schema.

The researcher utilized experts to investigate the correctness of the concepts on biology. Moreover, the researcher examined the definition, the defining attributes, the example and non-example, the taxonomy of the concept, the statement of principles and the vocabulary provided by the teacher during classroom discourses. Likewise, the four successive levels of concept attainment suggested by Klausmeier (1974) are determined.

Figure 1 gives the concept analysis by Teacher JTB. This concept analysis has the nearest representation of core proposition to that of the expert. It can be said the teacher's concepts about photosynthesis have reached the formal level of concept attainment. Examining the teacher's proposition about photosynthesis complied with the criteria set in the formal level. For instance, the teacher has attended the perceptible features of the event. She is able to discriminate between the different events that occur in the photosynthesis process. She generalized that the two phases of photosynthesis (Light and Dark) are part of the same process. She generalized that that two or more examples (plant, algae, photosynthetic bacteria) are equivalent and belong to the same class of thing (I.e., autotroph), discriminated the attributes of the class (autotroph) from those non-examples (heterotroph); hypothesized that all organisms that have chlorophyll are capable of photosynthesis.

This teacher also identified and differentiated examples and non-examples (Classificatory level). She established the correct terminology for the concept and its attributes during discussion. Acquiring the names of concepts and their attribute facilitates the attainment of concept at the higher level: formal level.

Analysis of Photosynthesis

A. Definition:
Photosynthesis is a process by which plants with the use of light energy and chlorophyll produce glucose, water and oxygen.

B. Defining attributes:
Process in chlorophyll-bearing organisms; use of energy and chlorophyll; production of glucose, oxygen and water; dark and light reactions; process taking place in chloroplasts

C. Irrelevant attributes:
Heterotrophs, the rest of the solar spectrum

D. Examples:
Autotrophic organisms: plants, algae, photosynthetic bacteria, etc.

E. Non-examples:
Heterotrophs, man

F. Taxonomy:

Supraordinate: Photosynthesis

Coordinate: In the presence of light and chlorophyll, water + carbon dioxide → glucose + oxygen + water

Subordinate: Light reaction (Photoactiviation, Photolysis); Dark reaction (Carbon dioxide fixation)

Taxonomy relationships:

1. Photosynthesis is a plant process of combining water and carbon dioxide in the presence of light and chlorophyll, producing glucose , oxygen and water.
2. The process involves light reaction and dark reaction.
3. Light reaction includes photoactivation and photolysis.
4. The products of photolysis are needed in carbon dioxide fixation.
5. The dark reaction involves carbon dioxide fixation.

J. Statement of principles (Teachers propositions):

1. Photosynthesis is a plant process of combining water and carbon dioxide in the presence of light and chlorophyll, producing glucose, oxygen and water.
2. Autotrophs are organisms that make their own food. Heterotrophs are organisms that depend on other organisms for food.
3. The equation for photosynthesis is as follows: $6CO_2 + 12H_2O \xrightarrow[chl]{light} C_6H_{12}O_6 + 6O_2 + 6\ H_2O$
4. In the light reaction, water undergoes photolysis due to the absorption of solar energy by chlorophyll. The chlorophyll is energized, causing the water to be photolyzed into H ions and oxygen.
5. The chloroplast is the photosynthetic machinery of the cell. It has grana and stroma. Chlorophyll, which is embedded in the grana of the chloroplast absorbs light energy. The grana are the sites for the light reaction and the stroma, for dark reaction.
6. In the dark reaction, the products of light reaction are needed to continue the process. Therefore, the dark reaction is dependent on the light reaction.

K. Vocabulary: Photosynthesis, chloroplast, photoactiviation, photolysis, carbon dioxide fixation, dark reaction, light reaction, chlorophyll

Figure 1. Concept Analysis of Photosynthesis, Teacher JTB

In this topic, most of the teachers provided the students with the same concepts and principles. In fact, some of the teachers like Teacher JTM were able to provide the application of the concept, encourage and guide student's discovery and independent evaluation by using the laboratory approach in her teaching. Thus, the teachers were able to provide formal level concept attainment to their students. This data imply that the teacher declarative knowledge in photosynthesis is sufficient to facilitate attainment of formal knowledge and therefore enhancement is not necessary.

Accordingly, students learn the teacher's declarative knowledge in three episodic sequences: (1) teacher declares his/her proposition/ideas; (2) provides imagery of his proposition/ideas; and (3) connects sequences and arranges the proposition in linear order. These three episodic sequences encompass his schema in teaching a topic. In this study, the researcher scrutinized the declarative knowledge of Biology teachers and found out the following finding as follows:

On Concept analysis:

1. The teacher's declarative knowledge in photosynthesis is sufficient to facilitate attainment of formal knowledge and therefore further enhancement is not necessary.
2. Some teachers, however, promote student concepts attainment up to identity level only, particularly on the topic cellular respiration and human reproductive system.
3. Some teachers are able to attain formal level, however, they do not have adequate information about the key concepts. This was observed particularly on the topic genetics.

On Proposition and Linear ordering

1. In photosynthesis, the teachers' concepts are almost similar to the expert's core concepts. The essential concepts are the definition of photosynthesis, the chloroplast, the light and dark and the dependence of the dark reaction on the product of light reaction. (However, there are concept errors in the list of propositions). There are also some concepts added by the teachers in their discussion aside from essential concepts suggested by experts (e.g., type of nourishment in the environment). This observation is also true in the other topics studied.
2. The teachers represent ideas in different forms and styles. Some represent ideas on logical sequence (I.e., definition of terms and the rationale about the sequence of the topic are discussed first to help the student understand each concept better. Others focus directly on the main content ideas.
3. It seems that the teachers who have master's degree and master's units in Biology have almost similar propositions and sequences to those of the experts.
4. Most of the teachers come up with inadequate propositions particularly genetics (Mendelian and Non-Mendelian) and Human Reproductive system. There are also core concepts recommended by the expert that are not found in the teachers' list of propositions. The teachers' proposition contain some misconception.
5. The teachers are knowledgeable in Photosynthesis and respiration; but they need improvement in other topics, such as genetics and reproduction, implying the need for further training or studies.

On Proposition and imagery

1. They utilize six methods to construct meaning of concepts: (1) simply defining; (2) using students' imagination; (3) using diagram or chart to define meaning; (4) using laboratory activities to construct meaning; (5) using natural phenomena as bases of constructing meaning; and (6) using quotation from textbook to construct meaning.
2. They use three methods to represent classification: (1) use of chemical equation to identify similarities and differences; (2) use of chart to illustrate difference; and (3) listing the differences and similarities.
3. They use four methods to represent relationship: (a) use of drawing and schematic diagram to identify part; (use of drawing to demonstrate sequence of event; (c) use of biography/history in tracing the development of the concept; and (d) tracing the steps in a process.
4. The use seven method to represent transformation: (a) use of practical problem; (b)use of chart to facilitate generic crossing; (c) use of mathematics to solve problem; (d) use of chemical equation;(e) laboratory experiment; (f) previous knowledge to solve problem and (g) use of diagram to analyze events.
5. They use three methods to represent causation: (a) use of Laboratory activity to demonstrate effect; (b)us of historical development to predict results and © use of mathematical deduction to interpret results.
6. They often modify definition and discussion in the textbook and express this in *Lingua franca* to be better understood by students.

7. The teachers' analogs given to students far from the things, object, event, or processes being compared to. This suggests that the teacher sometimes provides the condition for students' developing alternative conception through analogy/metaphors that they give.

<u>*On Schema*</u>

1. The teachers deviate from the lesson plan to accommodate students' interest and adjust to the actual situation during the lesson presentation. Thus, teacher needs to depend solely on their planned lesson but consider also other factors such as availability of facilities, actual classroom conditions, learner's preparedness for the lesson and other contributory factors that might affect their teaching during lesson implementation. This implies the need to anticipate such factors as well as they need to provide alternative plans (e.g., Plan B, Plan C) in case of emergency.
   Procedural knowledge is the second type of knowledge representation. It involves a specific procedure or set of action to accomplish the set goal. What the teacher does depends on the goal structure or specific step required. In this study procedural knowledge was studied only in connection with the way the teacher teaches how to solve problems. The data sources Indicate that teachers give problems that they have solve beforehand. They provide students with sequences of steps in a problem-solving lesson to facilitate analysis. They conduct laboratory activities for the purpose of verifying rather than discovering something new in connection to the topic to be taken in class. This defeats the purpose of laboratory activities. Only a few teachers use laboratory activity to represent a topic; and this is done only in connection with photosynthesis. The other teachers use only "thought experiment" and other representation techniques.

Congruence of Teachers and Students knowledge Structure

To statistically test the congruence of teacher's representation and student conceptual understanding before and after each representation of topic, the researcher utilizes non-parametric Kendall's tau Coefficient of agreement test. Table 6 shows the statistical analysis of agreement of teacher representation (based on their concept maps ranking scores) and student conceptual understanding (based on their post-instructional concept maps ranking scores).

Table 6. The Relationship between Teachers Representation and Student Conceptual Understanding as determine by Kendall's Tau

Topic	Computed Values				Interpretation
	Agreement P	***Inversion Q***	***Space***	***Tau***	
Photosynthesis	11	3	8	**.533**	Moderate of substantial agreement
Cellular Respiration	9	6	5	**.333**	Littl or small agreement
Humsn Reproduction	11	1	10	**.667***	Moderste or sunstanttial to high agreement
Mendelian Genetics	12	4	7	**.477**	Moderste or substantial agreement
Non-Mendelian Genetics	13	2	11	**.773***	Moderte or substantial to high agreement
All Topics	9	1	8	**.80***	High agreement

*Significant at alpha= 0.05

Table 6 is actually the Kendall's Tau coefficient result of each of the five topics. The hypothesis tested at alpha=.05 is that there is no significant relationship between the rankings of students' post instruction concept maps scores (Student conceptual

Understanding) and teachers' Concept maps after their lesson (Teacher Representation). Result indicates that all topics tested have moderate or substantial agreement, except in cellular respiration that has only little or small agreement. It is interesting however that, of the five topics, human reproduction and Non-Mendelian Genetics are significantly correlated at alpha= 0.05, the latter being highest at .773. What is noteworthy is the fact that Barquilla (2002) results that teachers are least knowledgeable in genetics seemed to contradict this result. It is highly probable, therefore, that they exerted extra effort to make their representation of genetics concepts interesting and challenging to students that the latter understood the concept clearly.

The results suggest that most of the topics (Photosynthesis, human reproduction, Mendelian, and Non-Mendelian Genetics) studied have moderate or substantial agreement between two groups. Pooling all topics, however, it is shown that there is high agreement between the teacher representation and students' conceptual understanding. Hence, the results suggest that teachers' representation does influence students' conceptual understanding.

CONCLUSION AND IMPLICATIONS

The study identified emerging patterns in this group of teachers. It is concluded that:

1. The teachers use the following strategies: (a) having meaningful learning objectives; (b) starting the class with stimulating activities relevant to the lesson; (providing student with concrete instructional material support; (d) presenting abstract concepts in a more personal and familiar concrete manner; and (e) finding application to the lesson in daily activities.
2. They spend more time in genetics (Mendelian and Non-Mendelian) as compared to those other topics under study. This must be due to the nature of the topics which require more time for analysis because of mathematical component.
3. They usually employ incomplete two-way pedagogy and teacher dominated student-teacher interaction, which does not develop and promote students' higher order thinking.
4. Most of the assessment questions of the teachers are simple recall and convergent questions. Furthermore, they rely on traditional methods of assessment.
5. During class discussion, the teacher does not always give students sufficient time to answer the questions they ask. Moreover, only a few encourage the students to ask questions themselves and answer them.
6. Teachers have their own unique teaching styles and strategies in promoting student conceptual understanding. Such teaching strategies and styles influence the teaching situations, the nature of the topic they discuss and belief in what strategies best fit the situation to make the student understand the topic they are teaching.
7. The teachers utilize six (6) methods to construct meaning of concepts, three (3) methods to represent classification, four (4) methods to represent relationship, seven (7) methods to represent transformation and three (3) methods to represent causation.
8. The teacher analogs given are sometimes far from the things, object, events or processes being compared.
9. They give the students only the problem that they have solved beforehand. They provide students with the sequences of steps in a problem-solving lesson to facilitate analysis.
10. They conduct laboratory activity for the purpose of verifying principles rather that discovering something new in connection to the topic to be taken up in class; and
11. Teachers' representation of Pedagogical content knowledge highly influences individual student conceptual understanding.

Based on these conclusions, it is implied that teachers in this area of concern need retooling and upgrading in order that the problem at hand of low performance of student can be properly address. The study identified weakness and strength of teachers as to their representation and pin down focus of teacher's training needs to facilitate improvement in student performance as the effects of teachers' representation. The Department of Education as the head agency for teachers' transformation may consider this study as basis for developing teachers training. Likewise, teachers may reflect their PCK if they were able to transform students' learning after their lesson implementation as they assess the overall impact of their lesson.

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