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Development and Validation of Learning Module with Integrated Improvised Laboratory Apparatuses (LMIILA) for Remote Learning in Science

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Abstract
This study introduced the printed learning module with integrated improvised laboratory apparatuses (LMIILA) for remote learning in science, bridging the gap for laboratory experiences during COVID-19 pandemic and for remote learning where stable internet connection is impossible. The LMIILA included electroscope and microscope developed and integrated in self-learning module piloted to seventy-five (75) Grade 10 students in Matabao, Agusan del Norte, Philippines. The study results showed that students enjoyed learning science while using LMIILA as it positively influenced their learning experiences.
Keywords: improvised laboratory apparatuses, remote learning, learning experiences in science
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1. Introduction

The concept of improvisation has become an increasingly popular and relevant topic in science as it deals practical issues like remote learning, contextualization, and resourcefulness. Teachers believed that students can achieve more with improvised materials, especially in science experiments (Luza-Tabiolo,2018). Various studies have proven that improvised laboratory apparatuses could offer the same functionality and effectiveness in doing experiments. Galiga (2019) developed an improvised apparatus for distillation for teaching and learning chemistry. The efficiency of the improvised apparatus is like that of standard apparatus as it gives the same functionality and purpose. Additionally, it is cheaper compared to the standard apparatus which offered comparable effectiveness though. However, Ndihokubwayo et al. (2018) concluded that improvised apparatus used during experiments have no impact on student's performance compared to students taught without science experiments, however, they clarified that even though there was no difference in terms of student performance, the students were more motivated and excited in using improvised materials.

2. Theoretical and Conceptual Framework

This study is anchored on David Kolb's Experiential Learning Theory where it posited that knowledge is created through transforming physical experiences. The theory has four (4) stages, concrete learning, reflective observation, abstract conceptualization, and active experimentation. The cycle of Kolb's theory is the framework used for the LMIILA. The LMIILA enables the students to have a concrete and physical experience of the concepts. Additionally, it helped students with active experimentation, as they could use the integrated apparatuses to test their ideas. Hence, the science experiments made possible by the LMIILA allowed learners to go through the entire cycle of David Kolb's Experiential Learning Theory.

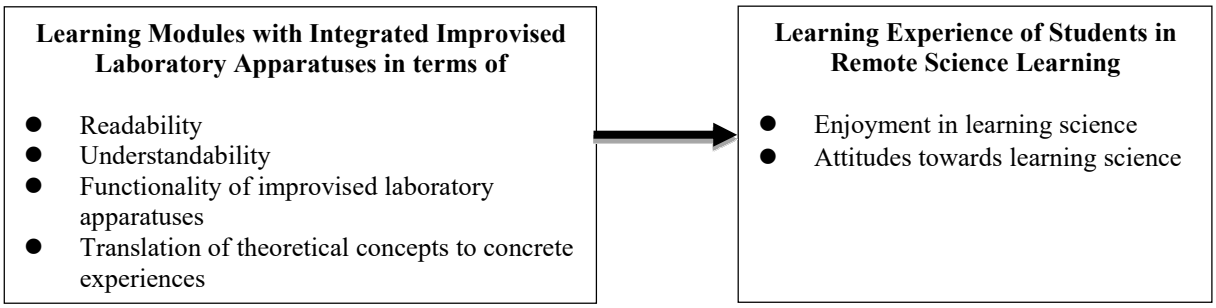

Figure 1. Schematic Diagram of the Study

The schematic diagram shows the relationship between Learning Modules with Integrated Improvised Laboratory Apparatuses (LMIILA) and students' learning experience in remote science learning. Characteristically, LMIILA possessed the qualities of readability, understandability, the functionality of the improvised apparatuses, and the ability to translate theoretical concepts into concrete experience, which in turn have affected the learning experience of students significantly.

3. Materials and Methods

This used a descriptive design. The study was conducted at Buenavista National Highschool located at Brgy, Matabao, Buenavista, Agusan del Norte, Philippines. The LMIILA was given to Grade 10 students. The study's sample size is seventy-five (75) randomly selected participants calculated using Cochran's Formula for sample size determination. The study utilized a survey questionnaire as its research instrument. The statistical tools used are average weighted mean, Pearson's r correlation test, and multiple linear regression analysis.

3.1 Improvised Electroscope

An electroscope is a device that can detect whether and object has a net electric charge.

The improvised electroscope utilized a small bottle, 10- gauge stranded copper wire, aluminum foil, illustration board, and a glue stick. The cost of each improvised electroscope is Php50 or 1USD.

3.2 Improvised Microscope

A microscope is a device that can enlarge images of microscopic objects.

Figure 3. Improvised Microscope

Figure 4. Lens of the Improvised Microscope

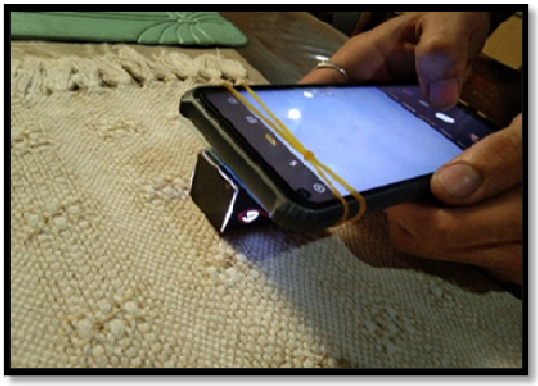

Figure 5. Using the Improvised Microscope

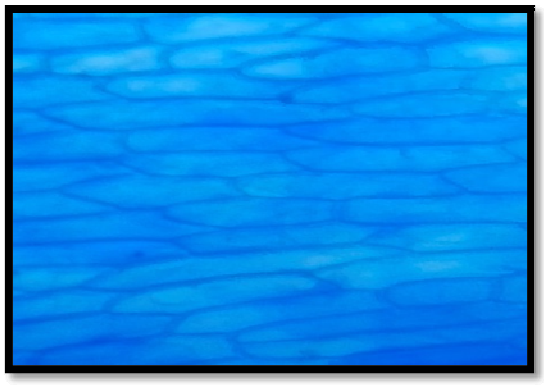

Figure 6. Onion epidermal cells magnified using the improvise microscope

The improvised microscope utilized a laser pointer, illustration board, cotton fibers, rubber band, light-emitting diode (LED), glass slide, glass coverslip, AAA batteries, 14-gauge stranded wire, hook up wire, and glue. The cost of each improvised microscope is 80 pesos and is a modification of Hewitt's (2013) laser pointer-based microscope.

3.3 Learning Module

The learning module was developed using the ADDIE model or the analyze design, develop, implement and evaluate model for instructional design. The learning module contained lessons, assessments, and laboratory activities on static electricity and the plant cell.

Integration of Improvised Apparatuses to the Learning Modules

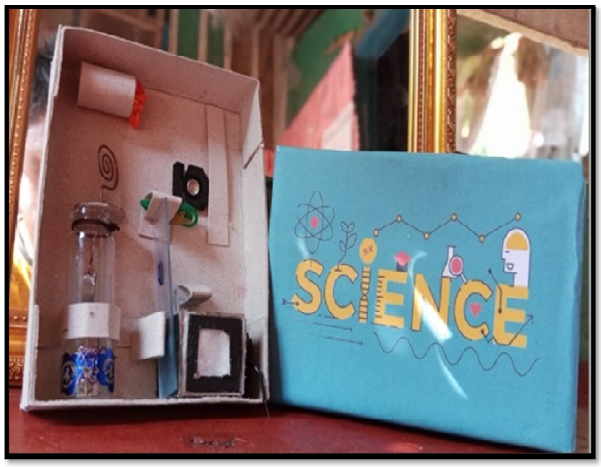

Figure 7. Improvised Laboratory Apparatuses

Figure 8. LMIILA

In integrating the improvised apparatuses into the learning modules, the apparatuses were contained in a chipboard box fixed by chipboard strips. They were then attached to the cover page of the learning module.

4. Results and Discussions

4.1 Quality of the LMIILA

Table 1 below shows the level of quality of the LMIILA in terms of readability, understandability, the functionality of improvised apparatuses, and the ability to translate theoretical concepts to concrete experience.

Table 1. Level of quality of LMIILA

Level of quality of LMIILA in terms of readability	**Mean**	**Remark**
Indicators		
1. The statements, phrases, and sentences in the LMIILA are well constructed, making them easy to follow and not hard to read.	3.5	Very high
2. The font size used in the LMIILA is large enough to read.	3.7	Very high
3. The page color and font color had a good contrast making it easy to read.	3.7	Very high
4. The figures in the LMIILA are enlarged enough to see.	3.7	Very high
5. The labels in the figures are enlarged enough to read.	3.7	Very high
6. The font color of the labels had a good contrast to the figures.	3.8	Very high
7. The pictures in the user manual of the improvised laboratory apparatuses are clear.	3.6	Very high
8. The background design of the LMIILA's pages is not distracting to the reader.	3.6	Very high
Weighted Mean	**3.7**	**Very high**

Level of quality of LMIILA in terms of understandability.			
Indicators			
1.	The learning contents on static electricity and charge are clear and understandable.	3.5	Very high
2.	The instructions of the laboratory activity "Detecting Static Charge with Electroscope" are clear and understandable.	3.6	Very high
3.	The instructions on using the improvised electroscope located in the user manual for the laboratory apparatuses are clear and understandable.	3.5	Very high
4.	The learning contents on plant cells are clear and understandable.	3.6	Very high
5.	The instructions of the laboratory activity "The Plant Cell" are clear and understandable.	3.5	Very high
6.	The instructions on using the improvised microscope located in the user manual for the laboratory apparatuses are clear and understandable.	3.5	Very high
	Weighted Mean	**3.6**	**Very high**
Level of quality of LMIILA in terms of functionality of improvised apparatuses.			
Indicators			
1.	The improvised electroscope can reliably detect the electric charge in objects.	3.4	High
2.	The improvised electroscope can easily be used.	3.5	Very high
3.	The improvised electroscope is durable and can last multiple testing and trials.	3.4	High
4.	The improvised microscope abled the user to see the cell wall, nucleus, and cytoplasm of the cell.	3.5	Very high
5.	The improvised microscope can be easily attached to the main camera of a phone	3.4	High
6.	The improvised microscope is durable to last for multiple testing and trials.	3.5	Very high
	Weighted Mean	**3.5**	**Very high**
Level of quality of LMIILA in terms of ability to translate theoretical concepts to concrete experience			
Indicators			
1.	The LMIILA can translate the discussion about static charge and electricity to concrete experiences of physically detecting static electricity and charge using the improvised electroscope.	3.6	Very high
2.	The learning content on static electricity and charge prepared students on the improvised electroscope's use and purpose.	3.6	Very high
3.	The transition between the discussion on static electricity and the laboratory activity "Detecting Static Charge with Electroscope" was not forced and was seamless.	3.4	High
4.	The LMIILA can translate the discussion about plant cells to concrete experiences through the physical observation of plant cells using the improvised microscope.	3.5	Very high
5.	The learning content on the plant cell prepared students to view plant cells and identify their parts using the improvised microscope.	3.6	Very high
6.	The transition between the discussion about plant cells and the laboratory activity" The Plant Cell" was not forced and was seamless.	3.5	Very high
	Weighted Mean	**3.5**	**Very high**

Mean Ranges: 1.0 –1.40 (Very low); 1.5 – 2.4(Low); 2.5 – 3.4(High); 3.5 – 4.0 (Very high)

The results above showed that all the measured qualities of the LMIILA are very high. This implied that the statements, phrases, and sentences in the LMIILA are well constructed, and the module's technical aspects like font size, figures, and labels are appropriate, thus can be read and seen. Furthermore, the learning contents and instructions on using the LMIILA were proven to be very understandable. Moreover, the improvised electroscope was easy to use and was able to last multiple trials and testing. Also, it was able to detect static charges in objects reliably. On the other hand, the improvised microscope effectively observed the cell wall, nucleus, and cytoplasm of the plant cell and was durable to be used multiple times. The improvised microscope can also be easily attached to the camera of a phone. Lastly, the LMIILA effectively translated the theoretical concepts presented in the learning modules to be observed.

4.2 Learning Experience of Students

Table 2 below shows students' learning experience in terms of their level of enjoyment and attitude towards learning science.

Table 2. Level of learning experience in using LMIILA.

Level of learning experience in using LMIILA in terms of enjoyment.	**Overall Mean**	**Remark**
Indicators		
1. The learning content on static electricity and the electric charge was enjoyable to learn.	3.6	Very high
2. Detecting static charges with the use of the electroscope was enjoyable.	3.6	Very high
3. Performing the laboratory activity "Detecting Static Charge with Electroscope" is enjoyable.	3.6	Very high
4. The learning content on plant cells was enjoyable to learn.	3.6	Very high
5. Physically seeing plant cells with the use of the improvised microscope was enjoyable.	3.6	Very high
6. Drawing plant cells with the aid of the improvised microscope was enjoyable.	3.4	High
Weighted Mean	3.6	Very high
Attitude towards learning science while using the LMIILA.		
Indicators		
1. The LMIILA increased my curiosity towards science.	3.7	Very high
2. The LMIILA increase my interest in science.	3.6	Very high
3. The LMIILA made me like science better.	3.5	Very high
4. The LMIILA made me more curious about the world.	3.6	Very high
5. The LMIILA made me realize that doing experiments is better compared to just being told scientific concepts.	3.5	Very high
6. The LMIILA made me want to take more science lessons	3.4	High
7. The LMIILA made me want to buy science-related materials.	3.3	High
8. The LMIILA made me want to do more science experiments at home.	3.5	Very high
Weighted Mean	3.5	Very high

Mean Ranges: 1.0 –1.40 (Very low); 1.5 – 2.4(Low); 2.5 – 3.4(High); 3.5 – 4.0 (Very high)

The students' learning experience using the LMIILA was proven to be very positive. This implied that the students highly enjoyed studying static charge and the plant cell while using the LMIILA. Furthermore, students highly enjoyed detecting static charge with the use of the improvised electroscope and seeing plant cells with the use of the improvised microscope. Moreover, students' attitude towards learning science while using the LMIILA was also observed to be very positive. This implied that the LMIILA increases students' curiosity and interest in science. Further, the LMIILA also made students want to take more science lessons and perform more science experiments at home.

4.3 Relationship Between the Learning Experience of Students in Terms of Enjoyment and the Quality of LMIILA

Table 3 below shows the significant relationship between the learning experience in terms of enjoyment and the level of quality of LMIILA.

Table 3. The Relationship between enjoyment and the level of quality of the LMIILA.

Variable 1	**Variable 2**	**Correlation Coefficient[a]**	**p-value**	**Decision**
Enjoyment	Readability	0.518	***0.000***	Significant relationship Strong and positive relationship
	Understandability	0.783	***0.000***	Significant relationship Strong and positive relationship
	Functionality of improvised apparatuses	0.758	***0.000***	Significant relationship Strong and positive relationship
	Ability to translate theoretical concepts to concrete experience	0.668	***0.000***	Significant relationship Strong and positive relationship

*Pearson r correlation coefficient: -1.0 to -0.5 or 1.0 to 0.5(Strong); -0.5 to -0.3 or 0.3 to 0.5 (Moderate): -0.3 to -0.1 or 0.1 to 0.3 (Weak); -0.1 to 0.1(None or very weak), * significant at α=0.05*

As shown in Table 3, there is a significant relationship between the level of enjoyment and all aspect of the quality of LMIILA at α=0.05. Moreover, each aspect of the quality of LMIILA has a strong and positive relationship with enjoyment. That is, as the quality of the LMIILA increases, the level of students' enjoyment increases.

4.4 Relationship Between the Learning Experience in Terms of Attitude Towards Learning Science and level of quality of LMIILA

Table 4 below shows the significant relationship between the learning experience in terms of attitude towards learning science and the level of quality of LMIILA.

Table 4. The relationship between the learning experience in terms of attitude and level of quality of the LMIILA.

Variable 1	Variable 2	Correlation Coefficient[a]	p-value	Decision
Attitude	Readability	0.463	***0.000***	Significant relationship Moderate and positive relationship
	Understandability	0.721	***0.000***	Significant relationship Strong and positive relationship
	Functionality of improvised apparatuses	0.602	***0.000***	Significant relationship Strong and positive relationship
	Ability to translate theoretical concepts to concrete experience	0.660	***0.000***	Significant relationship Strong and positive relationship

*Pearson r correlation coefficient: -1.0 to -0.5 or 1.0 to 0.5(Strong); -0.5 to -0.3 or 0.3 to 0.5 (Moderate): -0.3 to -0.1 or 0.1 to 0.3 (Weak); -0.1 to 0.1(None or very weak), * significant at α=0.05*

As shown in Table 4, there is a significant relationship between students' attitude towards learning science and all aspects of the quality of LMIILA at α=0.05. Moreover, the understandability, functionality of improvised apparatuses, and its ability to translate theoretical concepts to concrete experiences have a strong and positive relationship with students' attitudes. In contrast, the readability of the LMIILA has a moderate and positive relationship. That is, as the quality of the LMIILA increases, students' attitude towards learning science also increases and becomes more positive.

4.5 The Extent of the Influence of the LMIILA on the Learning Experience of Students in Terms of Enjoyment

Table 5 below shows the extent of the influence of the qualities of the LMILLA and the factors affecting students' learning experience in terms of enjoyment.

Table 5. Factors affecting the learning experience of the students in terms of enjoyment.

Variables	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	3.553	0.047	75.181	0.000
Readability	0.197	0.116	1.7	***0.094****
Understandability	0.458	0.125	3.677	***0.000*****
Functionality of improvised apparatuses	0.358	0.086	4.18	***0.000*****
Ability to translate theoretical concepts to concrete experience	0.026	0.122	0.214	0.831

*Model Assessment: R^2=0.715; ANOVA, F-statistic=43.851, p-value=0.000; parameter coefficients: *** significant at α=0.01 (highly significant); * significant at α=0.10*

The analysis result for students' enjoyment in learning science is shown in the table above. From the four factors considered that could influence the students' enjoyment, three are significantly associated and influenced the latter: readability, understandability, and functionality of improvised apparatuses.

To assess how good the obtained model, the coefficient of determination (R^2) and the significance of the model to predict the learning experience in terms of enjoyment were obtained. As observed, the obtained regression model has R^2=0.715, that is, 71.5% of the variability of the learning experience in terms of enjoyment can be explained by the model with predictor readability, understandability, and functionality of improvised apparatuses factors. Moreover, the regression model significantly predicts the learning experience in terms of enjoyment as the ANOVA results yield with F-statistic=43.851, p-value=0.000, which is highly significant at α=0.01.

As shown in Table 5, the readability, understandability, and functionality of improvised apparatuses are found to be significant factors affecting the learning experience in terms of enjoyment. Further, the significant factors have a positive relationship with the learning experience in terms of enjoyment. Thus, as the level of readability, understandability, and functionality of improvised apparatuses, the learning experience in terms of enjoyment also increases.

4.6 The Extent of the Influence of the LMIILA on the Learning Experience of Students in Terms of Attitude Towards Learning Science

Table 6 below shows the extent of the influence of the qualities of the LMILLA and the factors affecting students' learning experience in terms of attitude towards learning science.

Table 6. Factors affecting the learning experience of the students in terms of attitude.

Variables	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Constant	3.507	0.05	70.221	< .001
Readability	0.029	0.15	0.195	0.846
Understandability	0.576	0.162	3.561	***0 .000******
Functionality of improvised apparatuses	0.079	0.111	0.707	0.482
Ability to translate theoretical concepts to concrete experience	0.327	0.159	2.062	***0.043****

*Model Assessment: R^2=0.570; ANOVA, F-statistic=23.223, p-value=0.000; parameter coefficients: *** significant at α=0.01 (highly significant); ** significant at α=0.05*

The analysis result for students' attitude towards learning science is shown in the table above. From the four factors considered that could influence the students' attitude towards learning science, two are significantly associated and influenced the latter: understandability and ability to translate theoretical concepts to concrete experiences.

To assess how good the obtained model, the coefficient of determination (R^2) and the significance of the model to predict the learning experience in terms of attitude towards science were obtained. As observed, the obtained regression model has R^2=0.570, that is, 57.0% of the variability of the learning experience in terms of attitude towards learning science can be explained by the model with predictor understandability and the LMIILA's ability to translate theoretical concepts to concrete experiences. Moreover, the regression model significantly predicts the learning experience in terms of attitude towards learning science as the ANOVA results yield with F-statistic=23.223, p-value=0.000, which is highly significant at α=0.01.

As shown in Table 6, understandability and the LMIILA's ability to translate theoretical concepts to concrete experiences are found to be significant factors affecting students' attitudes towards learning science. Further, the significant factors have a positive relationship with the learning experience in terms of attitude towards learning science. Thus, as the level of understandability and the LMIILA's ability to translate theoretical concepts to concrete experiences increases, the learning experience in terms of attitude towards learning science should also increase and become more positive.

5. Conclusion

The results of the study show that the LMIILA has a positive effect on students' learning experience and proved that it is a potential solution to students' lack of laboratory experience in remote science learning. Furthermore, the improvised electroscope and microscope were effective in detecting static charge and seeing plant cells, respectively. Hence, the improvised apparatuses can be used in school laboratories with no functional electroscopes and microscopes. The study also proved the significance of physical laboratory activities in learning science as students were more engaged and more motivated to take science lessons with the LMIILA.

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