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Needs Assessment-Based Instructional Material on Non-Mendelian Patterns of Inheritance for Grade 9

Laura Francisco*and Manuel Barquilla
Department of Science and Mathematics Education, College of Education, Mindanao State University – Iligan Institute of Technology, Bonifacio Ave., Tibanga, Iligan City, 9200, Philippines
*Corresponding author's E-mail address: laura.francisco@g.msuiit.edu.ph

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Abstract

Students often struggle with understanding scientific concepts, particularly in Biology. This study was conducted to develop and evaluate an instructional module designed to address the least mastered competencies in Biology. Specifically, it aimed to construct a contextualized module on non-Mendelian patterns of inheritance and subject it to formative evaluation. The participants included 120 Grade 10 students and 5 Biology teachers from Hinaplanon National High School. Data were collected through a Biology Diagnostic Test, a learning style inventory, and a teacher needs assessment survey. Expert validation, the Fry Readability Graph (Fry, 1968), and the Romey Student Involvement Index (Romey, 1968) were employed to ensure the module's appropriateness and effectiveness. Results of the diagnostic test revealed that explaining different patterns of non-Mendelian inheritance was among the least mastered competencies, while students' preferred learning styles were solitary and visual. Based on these findings, a blended contextualized module was developed and evaluated by experts and students. The evaluation indicated that the module demonstrated high content validity, appropriate readability, and active student involvement. Overall, the findings suggest that the module is suitable for Grade 9 learners and can serve as a valuable resource for improving comprehension and engagement in Biology.

Keywords: *Blended, Contextualization, Least Mastered Competencies, Non-Mendelian Genetics*

1. Introduction

Globally, the Philippines lags behind other countries in the quality of education, particularly in science subjects (Millanes et al., 2017; Rogayan Jr & Dollete, 2019). The Philippines ranked 70th out of 144 participating countries in terms of the quality of mathematics and science education, according to the World Economic Forum by Schwab and Sala-i-Martín (2016).

Recently, the Program for International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD) in 2022 revealed that the Philippines ranked third (3rd) to last in Science which means that 77% of Filipino

students lack the ability to apply scientific knowledge. In science, the Philippines ranked 80th. The OECD average is at Level 3 or 485 score points but the Philippines is at Level 1a or a score of 356 (OECD, 2022).

In addition, the 2019 edition of the Trends in International Mathematics and Science Study (TIMSS) gave the Philippines scores of 297 and 249 in mathematics and science, respectively— the lowest among the 58 countries involved in the study (Mullis et al., 2020).

These international results coincide with the results of our National Achievement Tests (NAT) in recent years. In 2018, the national mean percentage score among Grade 6 pupils was only 37.44, the lowest in NAT history. This was a far cry from the 70.88 scores in 2015, which then plummeted to 42.03 in 2016 and 39.95 in 2017. Grade 10 scores suffered a similar downward trend, from 53.77 in 2014 to 44.08 in 2017, only minimally inching upward to 44.59 in 2018. Both grade levels are now in the "low mastery" category due to their latest NAT scores (Tagupa, 2019).

Students who study science frequently struggle with their poor grasp of scientific content, particularly biology. This is supported by a study by Großschedl et al. (2014), which found that helping students advance their knowledge of subjects like biology is the hardest thing for teachers to do. They mentioned that a variety of factors, including the students' motivation, IQ, and prior knowledge, have an impact on these challenges.

With this, Philippine education nowadays direly endeavors for quality instruction to address the deficiency inside the classrooms despite insufficient funds as constraints to cater to instructional materials needed (Legaspi, 2014) especially in every science subject. Intervention materials and other teaching instruction materials contribute a strong relationship with academic achievement and learning skills for students (Dahar, 2011) in science lessons which is considered a difficult subject to learn thus, student achievement in this area is affected much.

Instructional materials serve as an essential link between teachers and students, facilitating the effective delivery of lessons and sustaining motivation throughout the teaching-learning process (Adalikwu & Iorkpilgh, 2013). Within this framework, the concept of contextualization and localization often referred to in literature as contextualized teaching and learning (CTL) is consistent with the mandates of the Department of Education. As Bete (2018) explains, localization involves adapting and modifying content to suit local needs, address varying learning styles, fit different grade levels and disciplines, and align with cultural contexts, school curricula, and specific pedagogical goals.

Hence, the study was conducted not just to construct instructional material that will help support students in understanding the least mastered competences in Biology. Also, it is extended to the formative evaluation of the instructional material by utilizing experts from the field of Science and students in particular. Specifically, this study aimed to attain the following objectives:

1. Determine the least mastered competencies in Biology through a student's diagnostic test and teacher's needs assessment survey.
2. Determine the student's learning style as a basis for the development of the instructional material.
3. Develop instructional material focusing on one of the least mastered competencies in Biology.
4. Determine the validity of the developed instructional material in terms of its components such as:
    a. Content Validity
    b. Student Involvement Index
    c. Readability of the Module
    d. Communication Index for Words of the Module

This study is grounded in several theories that highlight the value of contextualized materials in enhancing the effectiveness and efficiency of the teaching–learning process. Motivation theory underscores the importance of connecting academic content with real-world experiences, as students become more engaged and interested when they perceive the relevance of what they are learning. In addition, social learning theory explains how students construct knowledge within a social context, emphasizing that meaningful learning often occurs through interaction, collaboration, and shared experiences (Fernandez et al., 2019).

2. Methods

This study utilized the descriptive survey method in determining the least mastered competencies in Biology through a diagnostic test questionnaire for the students and a needs assessment questionnaire for the teachers. While validating the developed instructional material, a questionnaire was also utilized according to its content validity, student involvement, and readability.

The researcher developed a Biology Diagnostic Test questionnaire that was used to assess the student's least mastered competencies in Biology. The questionnaire was then validated by three (3) Ph.D. professors and experts in Biology and Education from Mindanao State University- Iligan Institute of Technology. After validation, the researcher revised some questions according to the comments and suggestions of the research experts before seeking permission from the principal of Hinaplanon National High School to conduct pilot testing. A total of ninety (90) Grade 10 students who were not part of the research were the respondents for the pilot testing. For the teachers, an adapted semi-structured assessment questionnaire from Allonar (2023) was used.

During the implementation, there were one-hundred twenty (120) Grade 10 students from three (3) classes in Hinaplanon National High School who answered the diagnostic test and learning style questionnaire. While five (5) teachers from the same school were assessed for the needs assessment survey. To secure the confidentiality of the respondent's identities, this study assigned codes to each responder.

After the results from the diagnostic test and needs assessment survey were analyzed, an instructional material was developed focusing on one of the least mastered competencies in Biology. A researcher-made instrument was then utilized to validate the instructional material. The parameters of the said instrument are adapted from Talisayon and Yu (1997). It contains 20 items that are answerable on a five-point Likert scale to wit: 5 – Very High (VH) 4- High (H) 3 - Moderately High (MH) 2 – Low (L) 1 -Very Low (VL). Five (5) Science teachers from DepEd who have been in the field for 5-10 years evaluated the developed instructional material.

In addition, to determine if the developed instructional material was appropriate for the intended learners, Readability was determined using the Fry graph by Edward Fry (1968). To test if the material was appropriate for the intended learners, Romey (1968) was used to determine the Student Involvement Index.

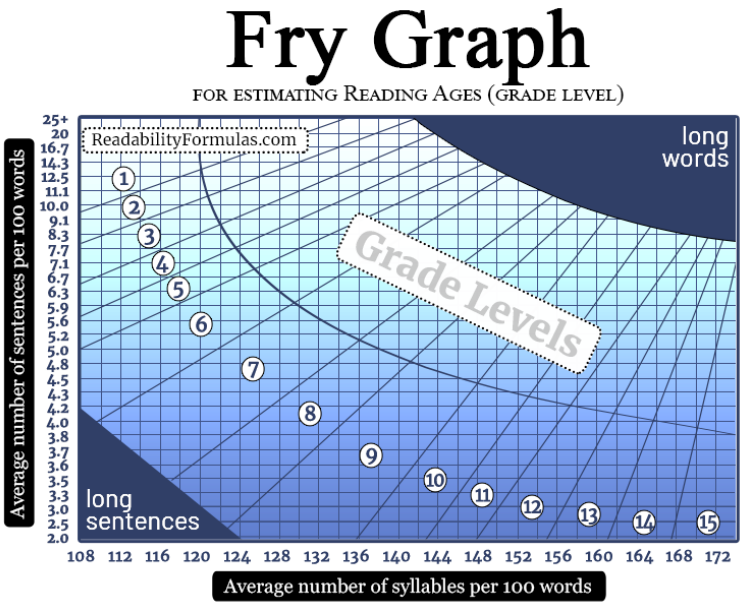

Figure 1. Fry Readability Graph

Moreover, the description of the results was analyzed based on the following description:

Mean	Description
4.21- 5.00	Very High
3.41 – 4.20	High
2.81 – 3.40	Moderately High
1.81- 2.80	Low
1.00- 1.80	Very Low

3. Results and Discussions

3.1 Least Mastered Competencies in Biology

After the pilot testing of the Biology Diagnostic Test questionnaire to a total of ninety (90) Grade 10 students, the responses were processed and subjected to a reliability test. Table 1 shows the reliability coefficient of the questions and indicates good internal consistency, which means that the items are highly correlated.

Table 1: Reliability Coefficient of the Biology Diagnostic Test questionnaire using Cronbach's Alpha

No. of Items	Cronbach's Alpha	Classification
40 items	0.8015	Very Reliable

After the pilot testing of the Biology Diagnostic Test questionnaire to a total of ninety (90) Grade 10 students, the responses were processed and subjected to a reliability test. Table 1 shows the reliability coefficient of the questions and indicates good internal consistency, which means that the items are highly correlated.

Moreover, after pilot testing and reliability tests, the researcher implemented a diagnostic test for one hundred twenty (120) Grade 10 students from three (3) classes in

Hinaplanon National High School. Results showed that the Grade 10 students had the least mastered competencies in Grade 9.

Table 2: Student's Least Mastered Competencies in Grade 9 Biology

Code	Learning Competency	Frequency	Percentage	Interpretation
S9LT-lab-26	Explain how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body	47	52.22	NM
S9LT-lc27	Infer how one's lifestyle can affect the functioning of respiratory and circulatory systems	19	21.11	UM
S9LT - Id - 29	Explain the different patterns of non -Mendelian inheritance	13	14.44	UM
S9LT - Id - 29	Explain the different patterns of non-Mendelian inheritance	14	15.56	UM
S9LT - Ie - f - 30	Relate species extinction to the failure of populations of organisms to adapt to abrupt changes in the environment	21	23.33	UM
S9LT - lg - j - 31	Differentiate basic features and importance of photosynthesis and respiration	29	32.22	UM

Based on the presented data in Table 2, the competency with the highest score acquired is in Explaining how the respiratory and circulatory systems work together to transport nutrients, gases, and other molecules to and from the different parts of the body (F=47, P=52.22). While the lowest score acquired is in Explaining the different patterns of non-Mendelian inheritance which only obtained (F=13, P=14.44) and (F=14, P=15.56).

This finding is similar to the result of a study by Delos Santos, et al (2021), the lowest mastery they have in grade 9 biology is explaining the different patterns of non-Mendelian inheritance (f=18) and describing the location of genes in chromosomes (f=10). The student's reasons for low mastery include a lack of interest in the topics, poor retention, poor conceptual understanding, and poor prior knowledge about the topic and not thoroughly discussed by the teacher. Protein synthesis, respiration, and photosynthesis, water transport in plants, physiological processes, energy, oxygen transport, gaseous exchange, mendelian genetics, organs, hormonal regulation, mitosis and meiosis, central nervous system, cells, and genetic engineering are multiple concepts in biology that high school learners can be perceived as difficult topics to learn (Çimer, 2012).

The student's result is supported by the gathered data from the teacher's semi-structured assessment interview for the least mastered topics in Biology. Table 3 shows that the least mastered topic in Biology is non-Mendelian Genetics where the common reason found behind this difficulty is the student's lack of basic knowledge regarding the topic. According to the teachers, the intervention that they think can help address this concern is to create instructional material focusing on the contextualization of the topic concerned. Trainings and seminars on this intervention are also a great help to provide

teachers with the necessary support that they need to deliver the appropriate knowledge and skills to the students. According to Picardal and Sanchez (2022), contextualization can be implemented across context groups and can improve students' learning and performance. Providing contextualization, localization, and indigenization in the country's K to 12 basic education system is crucial for immersing students in meaningful experiences that lead to better learning in science.

Table 3: Summary of Teacher's Responses on the Least Mastered Topics in Biology

Codes	Utterances
Common Topics with Difficulty and Misconceptions	**T1**: "Genetics (Non-Mendelian)" **T2**: "The topics in Genetics" **T3**: "Genetics, Punnett square, Non-Mendelian Genetics" **T4**: "About cell division"
Reasons for Difficulty in Learning	**T1**: "They lacked basic knowledge due to pandemic." **T2**: "Lack of resources for activities needed." **T3**: "They lacked basic ideas about these topics" **T4**: "The processes are not observable in daily basis"
Interventions to Address Challenges	**T1**: "Develop instructional materials that addresses the least mastered topics especially the basics." **T2**: "Contextualized learning materials and resources" **T3**: "More activities, problem-based activities" **T4**: "Show video presentations, provide games, and interesting activities."
Support Needed	**T1**: "Money, trainings, seminars, and instructional materials." **T2**: "Trainings and seminars on developing appropriate learning materials" **T3**: "Instructional materials like videos or games" **T4**: "Trainings and seminars for contextualizing topics"

3.2 Student's Preferred Learning Style

With the results on the least mastered competencies, the researcher determined the student's learning style as a basis for the development of the instructional material. Figure 2 shows the preferred learning style of the students.

As depicted in Figure 2, students were presented with seven (7) distinct learning styles to select from: solitary, social, logical/mathematical, physical/kinesthetic, verbal, musical/auditory, and visual. Among these, the top two (2) favored learning styles among students were solitary (73) and visual (72). The students displayed a preference for independent study or working alone, as well as an inclination toward utilizing visual aids such as pictures, images, and spatial comprehension as key elements in their learning approaches. According to Raiyn (2016), visual learning also helps students to develop visual thinking, which is a learning style whereby the learner comes better to understand and retain information better by associating ideas, words, and concepts with images. On the other hand, solitary learners, also known as intrapersonal learners, tend to prefer working independently and often excel in self-directed study environments. They thrive when given the autonomy to learn at their own pace, without the need for extensive interaction with others.

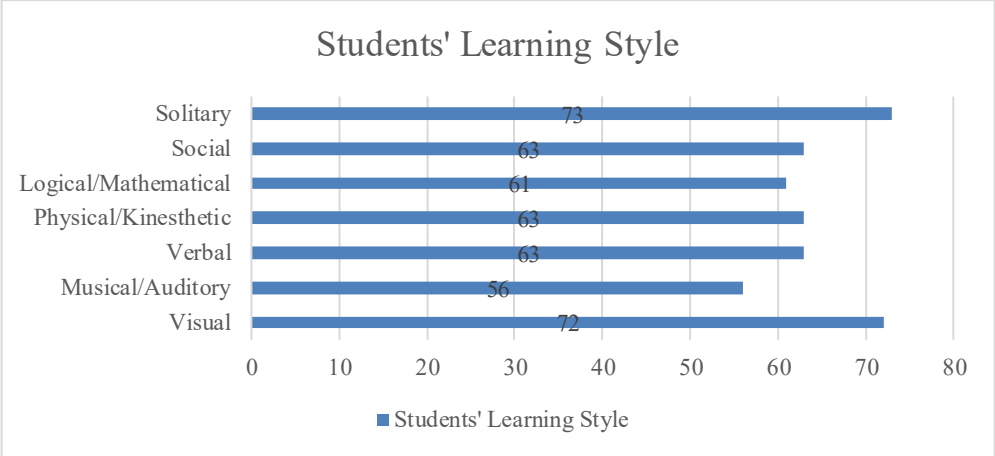

Figure 2. Student's Learning Style

Consequently, the purpose of education needs a radical shift in providing primary education that fits the insistence of the 21st century. It suggests that DepEd or any related organizations that are ideally concerned with education, instead of trying to provide young generations with the knowledge they need, the role of education is to train people with the tools and skills to acquire knowledge themselves. With that, learners must be self-reliant and adapt to the rapid change around them (Cangelosi, 2015; Rao, 2016; Reader, 2018).

3.3 Development of a Blended Contextualized Learning Module on Non-Mendelian Patterns of Inheritance

With the previous findings on the least mastered competencies in Biology and the student's learning style, the researcher developed a blended contextualized learning module on non-Mendelian patterns of inheritance.

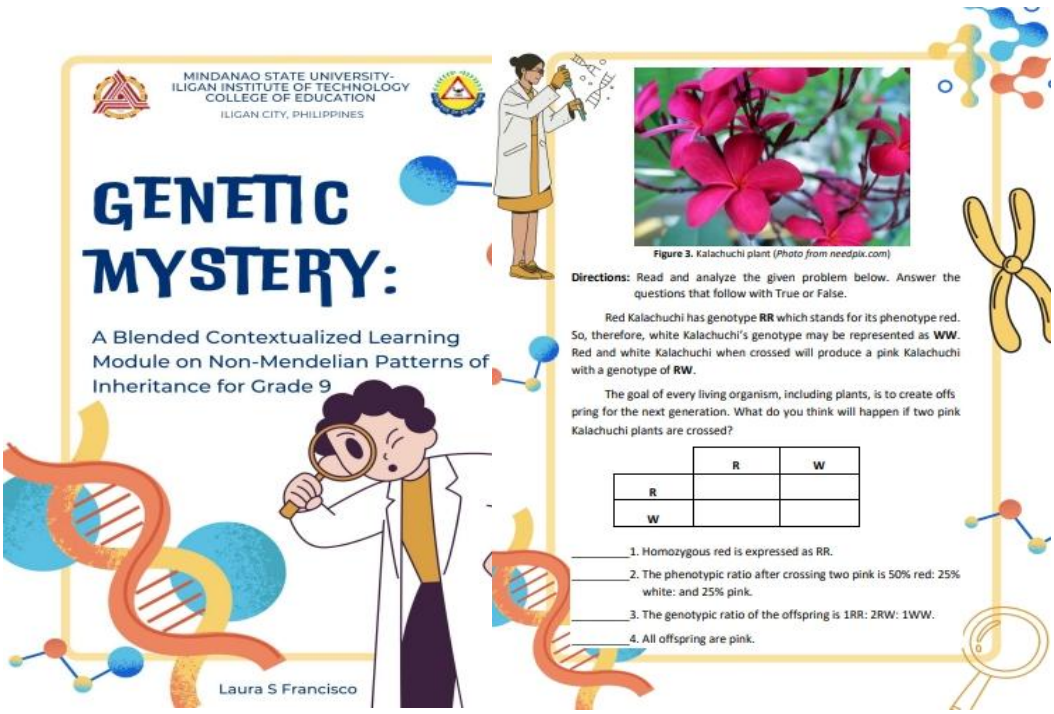

Figure 3. Cover Page and Sample Activity of the Blended Contextualized Module

The blended contextualized module is designed to accommodate students' preferred learning styles effectively. It integrates visual elements such as images and pictures, catering to the needs of visual learners. Furthermore, this module enables personalized learning paths, allowing students to progress at their own pace beyond regular school hours. Simultaneously, it offers in-person interactions and activities supported by teachers during classroom sessions, fostering a diverse learning environment that meets various learning needs. Also, this module is a contextualized module to design a learning environment that is more meaningful, engaging, and applicable, enhancing students' understanding and retention of the material while fostering a deeper connection between the content and their own experiences. In addition, the researcher adapted and modified the seven (7) elements used in developing a learning module from the DepEd (2020): Title page, Table of Contents, Pre-test, Introduction, Learning Activities, Assessment/Evaluation, and References.

3.4 Evaluation for Validity of the Developed Blended Contextualized Learning Module on Non-Mendelian Patterns of Inheritance

After the development of the blended contextualized module on non-Mendelian patterns of inheritance, it underwent validation from five (5) experts and student evaluators in terms of (a.) content validity/congruence of curriculum materials with its objectives, (b.) student involvement in the module (c.) cognitive demand of the module, and (d.) readability of the module.

a. Content Validity/Congruence of Curriculum Materials with Its Objectives

Evaluator's Formative Evaluation

Table 4: Validation of Module as to the Attainment of Objectives

ATTAINMENT OF OBJECTIVES	MEAN
1. The objectives of the module are clearly stated	4.8 (VH)
2. The objectives are attainable within the prescribed time.	4.8 (VH)
3 The activities and evaluation are congruent with the objectives.	4.6 (VH)
AVERAGE	**4.733 (VH)**

Based on Table 4, the module was rated very high as to the attainment of the objectives with a mean of 4.7333. It shows that the objectives are clearly stated and attainable within the prescribed time. The activities and evaluation also has a very high congruency with the objectives. In order to engage students in deep learning approaches, the constructive alignment between the learning objectives, the learning activities and the assessment should be reviewed and considered in ways so that students do not skip the learning process and activities in order to focus on the essential elements that will help them pass the activity's assessment process (Roméro & Kalmpourtzis, 2020).

Table 5: Validation of Module as to the Accuracy of the Contents

ACCURACY OF THE CONTENTS	MEAN
1. The contents are well-organized and well-prepared.	4.8 (VH)
2. The sample problems, activities, and evaluation go well together with the discussion.	4.8 (VH)
3. The contents are accurate and appropriate to the level of students indicated.	4.8 (VH)
4. It is interesting and self-motivating.	4.6 (VH)
5. The concepts and ideas conveyed are correct and accurate.	5 (VH)
AVERAGE	**4.8 (VH)**

As indicated in Table 5, the module was rated very high as to the accuracy of the contents with a mean of 4.8. It shows that the contents of the module are well-organized and well-prepared. Also, the discussion in the module is in congruence with the sample problems, activities and evaluation. The results imply that the module is accurate and appropriate to the level of the target students and conveys correct and accurate concepts and ideas. One of the most important things is to make sure that the material is engaging and interesting for both the teacher and the students. If it is something that everyone enjoys using, then it will be more likely to be used on a regular basis. It is also important to make sure that the material is appropriate for the age group and level of ability of the students. There should be a balance between challenge and support so that all students can get something out of it (Lane, 2022).

Table 6: Validation of Module as to its Originality

ORIGINALITY	MEAN
1. The module is original in its kind.	4.2 (H)
2. The author properly recognizes the sources of information used.	5 (VH)
3. The design and arrangement are unique	4.8 (VH)
AVERAGE	**4.666 (VH)**

Based on Table 6, the module was rated very high as to its originality with a mean of 4.666. This implies that the author properly recognizes the sources of information in the module and the designs and arrangement are unique. A lower rating however is given to the module in terms of it being original in its kind with a rating of 4.2, yet, still has a description of high. Originality means that a work was independently created by the author. This covers books and other writings, musical works, films, paintings and other visual arts, architectural designs, computer programs, and other literary and artistic works (Intellectual Property Office of the Philippines, 2019).

Table 7: Validation of Module as to its Clarity

CLARITY	MEAN
1. The contents are clearly stated and easy to comprehend	4.8 (VH)
2. The illustrations are vivid and clearly described.	4.8 (VH)
3. The ideas are in order and properly sequenced.	4.8 (VH)
4. The module conveys the ideas in a very understandable manner.	5 (VH)
5 The descriptions of the activities are clear and doable.	4.6 (VH)
AVERAGE	**4.8 (VH)**

As presented in Table 7, the module was rated very high as to its clarity with a mean of 4.8. This implies that the contents are clearly stated and easy to comprehend for the target users. The ideas in the module are properly sequenced and conveyed in a very understandable manner. In addition, activities are doable and the illustrations used are clearly presented. One of the most effective ways to enhance students' learning is by clarifying what the students should know and modeling how they can come to know those things (Gotlieb, 2019).

Based on Table 8, the module was rated very high as to its appeal with a mean rating of 4.85. It shows that the topics and ideas are properly sequenced and that the module is very appealing and gives interest to the learners. Impactful images, research shows, help to retain knowledge in a visual person's long-term memory as shapes and colors are more likely to be associated with emotions than simple text (Rudnicka, 2022).

Table 8: Validation of Module as to its Appeal

APPEAL	MEAN
1. The illustrations are attractive that give interest to the readers	4.6 (VH)
2. The appearance of each page is eye-catching and appealing.	5 (VH)
3. The ideas are in order and properly sequenced.	4.8 (VH)
4. The arrangement of the topics persuades the reader to read more.	5 (VH)
AVERAGE	**4.85 (VH)**

Moreover, the experts have also given some feedbacks on the module, these are: *(a) the module provides factual information and contextualized activities, (b) the module is visually appealing and with clearly stated objectives, (c) the module is well-organized structure, (d) the module is very articulated and scientific,* and *(e) incorporate more examples of plants and animals that are common in the local area.*

Student's Formative Evaluation

Table 9: Student's Formative Evaluation on the Developed Module

Criteria	Mean	Adjectival Value
Clarity and Difficulty		
1. The instructions are clear and understandable.	2	Agree
2. The words used are easy to understand.	1.6	Agree
3. The tables and pictures used are clear and easy to understand.	3	Strongly Agree
4. The ideas are in order and properly sequenced.	1.6	Agree
5. The ideas shared are easy to understand.	2	Agree
Appeal		
1. The size and font of letters is appropriate and easy to read.	3	Strongly Agree
2. The module is attractive and appealing.	2	Agree
3. The design used are appropriate to the topic and not distracting.	2	Agree
4. The illustrations are attractive that give interest to the readers.	2	Agree
5. The appearance of each page is eye-catching and appealing.	2.2	Agree
Overall, I am satisfied with the quality of this module.	**3**	**Strongly Agree**

Legend: 0 - 0.75 Strongly Disagree (SD) 1.51 – 2.25 Agree (A)
0.76 – 1.50 Disagree (D) 2. 26 – 3. 00 Strongly Agree (SA)

As presented in Table 9, the students' feedback for the module in general is *Strongly Agree* on the two criteria in terms of clarity and difficulty, and appeal with an overall weighted mean of 3. The students were satisfied with the quality of the module. Specifically, on the student's viewpoint there is clarity on the instructions given every activities and the ideas are properly sequenced and easy to understand. On the appeal, the overall design and appearance of the module is appropriate and not distracting.

b. Student Involvement in the Module

As shown in Table 10, the total number of sentences for Category I is 49. For Category II, the total number of sentences is 35. Based on these data, the calculated student involvement index is 0.714. This value falls within the range identified by Romey (0.4-1.5). The result indicates that the developed contextualized module on non-Mendelian patterns of inheritance helps students in analysis, thinking, and induction. Involvement of the reader in the material makes it interesting. Interesting tasks develop students' reading skills and positive attitudes much more effectively than the tasks they find unattractive (Merisuo-Storm & Soininen, 2014).

Table 10: Student Involvement Index of the Module

Category	No. of Sentences										TOTAL
I.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1. Facts	4	4	5	3	4		7	2	1		30
2. Stated conclusion		1	1	2				2			6
3. Definitions		3		5			3		2		13
4. Questions answered immediately											0
Total for I	**4**	**8**	**6**	**10**	**4**	**0**	**10**	**4**	**3**	**0**	**49**
II.											
5. Questions requiring students to analyze data		1	1		1	3				2	8
6. Statement requiring student to formulate conclusions			1		5	10			2		18
7. Directions to students to perform and analyze some activity and solve problems		2			1	1		1	1	1	7
8. Questions to arouse student answer and not answered immediately		2									2
Total for II	**0**	**5**	**2**	**0**	**7**	**14**	**0**	**1**	**3**	**3**	**35**

$$Student\ Involvement\ Index = \frac{\text{Total of Category II}}{\text{Total of Category I}} = \frac{35}{49} = 0.714$$

c. Readability of the Module

Table 11: Readability Result of the Module

	No. of Sentences	No. of Syllables
First Page	5	161
Middle Page	6	134
Last Page	5	151
Average	**5.333**	**149**

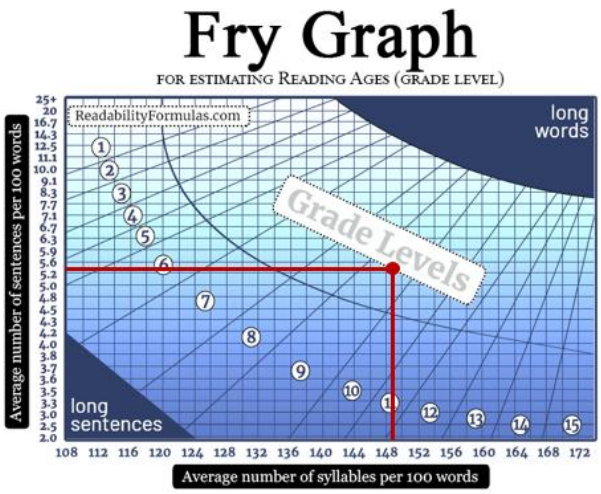

Figure 4. Fry Graph for the Readability Result of the Module

The Fry Graph's representation of the average number of sentences and syllables (Table 11) indicates a calculated readability of 5.333/149, aligning well with the proficiency expected at a Grade 9 level for students. Therefore, this suggests that the created module suits the intended students appropriately. The readability of the module is an important quality for the comprehension of the intended learners (Woo, 2015).

d. Communication Index for Words of the Module

The researcher tabulated the instances where the respondents highlighted unclear words within the three 100-word samples specified in Table 11. This also involves tallying the number of readers or trial students who found certain words unclear the entire sample. This comprehensive analysis is performed for every unclear word within the provided sample set. The total number of words, Nx, is 300 words (3 samples x 100 words per sample). Also counting the total number of readers, Nr. Below is the communication index, CI, for words of the module (Talisayon, 1983):

$$CI = \frac{Sum\ of\ (fX)}{(Nr)(Nx)}$$

N = no. of readers indicating a given unclear word
f = no of times unclear word appear in the samples of words
Nr = total number of readers
Nx = total number of words in the samples

There are 6 words (***fostering, inquisitive-2times, anchored, extremities, polygenic,*** and ***hesitate***) that are found unclear out of 300 words in the three samples. Among the 6 unclear words, the word "inquisitive" appeared three times from the samples. Further, a single student who found these words unclears.

$$CI = \frac{(1)(1)(1) + (1)(1)(2) + (1)(1)(1) + (1)(1)(1) + (1)(1)(1) + (1)(1)(1)}{(300)(6)}$$
$$= 0.003$$

The Communication Index of the module is 0.003 between the acceptable values for CI. The range of acceptable values for CI is: $0 \leq CI \leq 0.1$. Thus the communication index of the module is agreeable and acceptable.

4. Conclusion

Based on the results of the diagnostic test, one of the least mastered competencies in Biology is on explaining the different patterns of non-Mendelian inheritance and the student's preferred leaning styles are solitary and visual. With this the researcher developed a blended contextualized module on non-Mendelian patterns of inheritance.

Following an extensive assessment encompassing content validity/congruence of curriculum materials with its objectives, student involvement in the module, cognitive demand of the module, and readability, the module demonstrates suitability and acceptance for its intended recipients—Grade 9 students. The outcomes from the student involvement index indicate that this module effectively supports analytical thinking and inductive reasoning among learners.

Additionally, feedback from students highlights the module's design and appearance as fitting and non-distracting, affirming its overall appropriateness. As a recommendation, it is suggested that the developed module focusing on non-Mendelian patterns of inheritance should be implemented across both public and private educational institutions.

This implementation aims to increase students' comprehension and retention while fostering a stronger integration between the subject matter and their personal experiences.

The findings of this study carry significant implications for Biology education. The developed module not only improves students' comprehension of non-Mendelian inheritance but also aligns with their preferred learning styles, demonstrating the importance of integrating differentiated instructional strategies to address diverse learners' needs. Furthermore, the effectiveness of contextualization in this module highlights its role in making abstract genetic concepts more concrete and relatable, thereby promoting deeper scientific literacy and equipping students with the analytical skills necessary for advanced studies in the life sciences.

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