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Enhancing Students' Conceptual Understanding of Mutation Through the Utilization of Strategic Intervention Material (SIM): An Action Research Study

Jenny A. Allonar*, Douglas A. Salazar, Monera A. Salic-Hairulla

College of Education - Department of Science and Mathematics Education, Mindanao State University – Iligan Institute of Technology, Iligan City
*Corresponding author email: jenny.allonar@g.msuiit.edu.ph

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Abstract

This study investigated the effect of Strategic Intervention Material (SIM) on the conceptual understanding of mutation in Grade 10 students, compared to conventional learning modules. The research was conducted during the 2024 National Learning Camp at Hinaplanon National High School in Iligan City, involving 44 students divided into experimental and control groups. A quasi-experimental research design was employed, integrating both quantitative and qualitative methods. The experimental group utilized the SIM, while the control group used the DepEd learning module. Results showed that students exposed to SIM achieved significantly higher posttest scores (mean = 11) than those in the control group (mean = 7.77). Qualitative feedback revealed that students found the SIM more engaging, visually appealing, and easier to understand than the conventional module. The study concludes that SIM is an effective pedagogical tool for improving students' conceptual understanding of mutations. It is recommended that SIMs be integrated into the regular biology curriculum and further evaluated for broader implementation.

Keywords: Action Research, Conceptual Understanding, Mutation, Strategic Intervention Material (SIM)

1. Introduction

Biology is one of the core subjects in high school and is pivotal to one's education (Junco & Nabua, 2023). In biology education, genetics remains one of the least mastered subjects in modern education despite its pivotal role in understanding life sciences and its applications in various fields (Jones et al., 2019). However, the core of Genetics lies in understanding the concepts of the Central Dogma of Molecular Biology. Understanding this topic at the secondary level is critical, and it serves as a foundation for other higher-level concepts in biology, as well as the ability to integrate biological processes occurring at the cellular and organismal levels (Tabotabo-Picardal & Pano, 2018). Although this topic is considered essential to the field, many professors and students struggle to grasp its abstract principles. According to Kate Wright et al. (2014), this subject is still challenging to teach and poorly understood by teachers and students.

Traditional teaching methods often fail to engage students effectively, resulting in limited retention and understanding of genetic principles (Brown & Miller, 2019). The utilization of Strategic Intervention Materials (SIMs) presents a promising approach to address this educational challenge. SIMs, when strategically designed and implemented, have demonstrated efficacy in enhancing student engagement, conceptual understanding, and knowledge retention across various academic disciplines (Gupta & Bharti, 2017; Tan & Wong, 2020).

However, despite the potential of SIMs, their specific application and impact in the context of genetics education remain underexplored. There is a pressing need for empirical research that investigates the development and implementation of tailored SIMs in genetics education settings to evaluate their effectiveness in improving student learning outcomes and mastering complex genetic concepts. Addressing these gaps is crucial to empower educators with innovative pedagogical tools that can effectively enhance students' mastery of genetics, thereby fostering a more proficient understanding of this crucial scientific discipline.

Moreover, the researcher had developed a Strategic Intervention Material (SIM) based on the students' least mastered competency and preferred learning style. The developed instructional material underwent an extensive evaluation encompassing content validity or congruency of curriculum materials with its objectives, student involvement in the module, cognitive demand of the module, and the readability of the module.

1.1 Objectives

This study aimed to determine if there is a significant difference between the conceptual understanding of students exposed to SIM and a conventional learning module. Specifically, this study sought to address the following objectives:

1. Determine the conceptual understanding of the students exposed to the conventional learning module and those exposed to the developed SIM.
2. Determine the significant difference in conceptual understanding between students exposed to the conventional learning module and those exposed to the developed SIM.
3. Determine the perception of students on the developed SIM.

1.2 Scope and Limitations

This study compared conventional learning materials from DepEd (control group) with a Strategic Intervention Material developed by the researcher (experimental group) to enhance students' conceptual understanding of mutation. Conducted with incoming Grade 11 students at Hinaplanon National High School during the NLC from July 1-19, 2024, under the Consolidation Camp, the study faced several limitations due to time constraints. It focused exclusively on point mutations and their impact on protein structure and function (S10LT - IIIe -38), excluding chromosomal mutations. The implementation period was 2 weeks, aligning with the students' busy NLC schedule and the Science MELCs, which designated a 2-week duration for that specific lesson.

In addition, a 15-item test questionnaire on mutation was administered, with only posttests given to the two participating classes. Pretests were not feasible, as the short duration of the study could have led to students remembering pretest questions, potentially affecting the results. Finally, qualitative data collected from interviews were presented as field notes because the small number of respondents did not allow for theme generation.

1.3 Null Hypothesis

H0: There is no significant difference in the conceptual understanding of students exposed to the conventional learning module and the Strategic Intervention Material.

2. Methods

2.1 Research Design

The research design employed in this study is a quasi-experimental method, incorporating both quantitative and qualitative research. A quantitative approach was used to collect standardized and measurable data on the achievement test scores of the Grade 10 students in Mutations. On the other hand, a qualitative approach was used to collect data on the students' perceptions of the developed SIM.

2.2 Research Locale and Respondents

This study was conducted at Hinaplanon National High School, Hinaplanon, Iligan City, Lanao del Norte. The participants of this study were the Grade 10 junior high school students who participated during the National Learning Camp (NLC) held in July of 2024. The students were divided into 2 groups, the experimental and control groups. The experimental group was exposed to the developed SIM while the control group was exposed to the conventional learning module. This study utilized the purposive sampling technique in choosing the participants of the study. Moreover, before conducting the survey, permission and consent were obtained from the school principal and the students, who agreed to participate voluntarily in the study.

2.3 Research Instruments

To obtain sufficient data to support the objectives of this study, the following tools were used:

1) Test Questionnaire on Mutations.

One research instrument utilized in this study was a 15-item Test Questionnaire adopted from DepEd (2020). The test includes the types of point mutations for the whole duration of the study. The questionnaire was administered to both experimental and control groups. Table 1 was used to interpret the data and as a basis to classify and determine the description of the intervals they belong.

Table 1: Conceptual Understanding Classification

Score Range	Rating	Classification
14-15	90% - 100%	Outstanding
13	85% - 89%	Proficient
12	80% - 84%	Approaching Proficient
11	75% - 79%	Developing
10-0	Below 75%	Beginning

Table 1 indicates the achievement test score ranges, percentages, and conceptual understanding classification. This was based on the K-12 curriculum grading system approved by the Department of Education. The score ranges were set based on the number of items on the test questionnaire, with the lowest interval, 0-10, classified as 'Beginning' and the highest interval of 14-15 classified as 'Outstanding'. This table was used to determine the classification of the students' conceptual understanding of Mutations based on their scores.

2) Learning Module (Control Group)

This study utilized the First Edition (2020) of the Science Module on Mutation from DepEd for the control group. Due to time constraints, the instruction was limited to the types of point mutations, excluding chromosomal mutations. This module was used to evaluate whether there is a significant difference in the conceptual understanding of

students exposed to SIM compared to those using the conventional standardized learning module.

3. Strategic Intervention Material (Experimental Group)

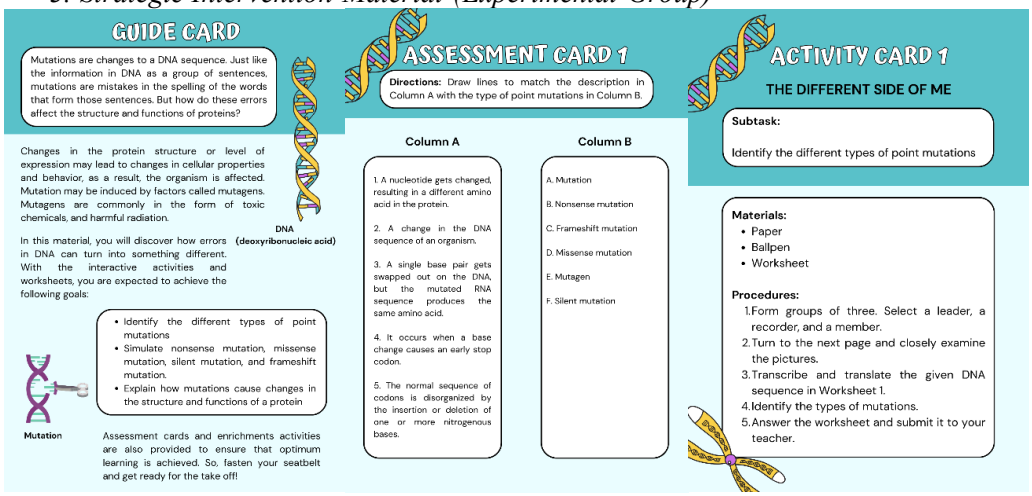

Figure 1. Sample Features of the Strategic Intervention Material (SIM) on Central Dogma

Figure 1 shows the sample features of the Strategic Intervention Material (SIM) on the "Central Dogma" made by the researcher as a supplementary material to enhance the conceptual understanding of the Grade 10 students on the topic. Strategic Intervention Material, or more commonly known as SIM in Philippine Education, is one of the solutions employed by the Department of Education to improve the academic performance of students in science. SIM is an instructional material intended to re-teach lessons and concepts that are least mastered by students (Suarez & Casinillo, 2020; Bonitez, 2021; Diaz & Dio, 2017).

The SIM contains the Central Dogma and the Types of Point Mutations. The Most Essential Learning Competencies (MELCs) were considered in designing and conceptualizing the SIM on Genetics. Afterward, the chosen topics and activities included in the study were mapped onto the learning competencies from DepEd's MELCs.

Also, the researcher adapted the steps in developing a SIM from DepEd (2005). There were seven (7) elements in developing a SIM. These are (1) Title Card, (2) Guide Card, (3) Activity Card, (4) Assessment Card, (5) Enrichment Card, (6) Reference Card, and (7) Answer Card. This intervention material aims to develop the student's conceptual understanding of the least learned competency of a particular subject or area. It can also be used as supplementary material and for remedial purposes.

4. Semi-Structured Interview Questionnaire.

A semi-structured interview questionnaire was utilized to gather the qualitative data for this study—the questions centered on the conventional learning module and the Strategic Intervention Material. A focus group discussion was conducted to validate the results of the students' scores.

2.4 Data Gathering Procedure

To guarantee the credibility of the research process before collecting data, a letter was prepared addressed to the school principal of Hinaplanon National High School to ask for permission to conduct the study. Consent letters addressed to the students were also given. Upon the approval of the school, two sections from the Grade 10 level were selected as

the study participants. The students were grouped accordingly to form the desired groups. In addition, the overall group's mean of their grades was computed to ensure that the experimental and control groups were comparable.

Table 2: Distribution of Students by Group and Science Ability

Group	n	Overall Group Mean	Interpretation
Experimental	22	81.24	Approaching Proficient
Control	22	80.41	Approaching Proficient

Table 2 shows the average grade of the students in science from SY 2023-2024, for whom the students were previously enrolled. Furthermore, Table 1 shows that the overall group mean ratings of the experimental and control groups are 81.24 and 80.41, respectively, which implies that the groups are not different regarding science ability. This means that the students in this study need to improve their conceptual understanding of Mutations.

Then, the students were oriented about the objectives of the study. The two classes were conducted for 30 minutes per day during their lunch break for 2 weeks. The Strategic Intervention Material was introduced only to the experimental group while the conventional learning module was given to the control group. Upon completing the activity, a 15-item test questionnaire on mutations was administered to gather quantitative data. For the qualitative data, the researcher conducted a focus group discussion based on an interview guide and provided a feedback slip for learners to share their insights.

2.5 Data Analysis

Quantitative and qualitative analyses assessed the conceptual understanding of students exposed to the Strategic Intervention Material (SIM) and the conventional learning module. Mean calculations were used to evaluate the comparability of the two classes. To determine the significance of the difference in post-test results between the groups, the Mann-Whitney non-parametric test was conducted, with the hypothesis tested at a 0.05 significance level.

For the qualitative aspect, data collected from interviews were presented as field notes because the small number of respondents did not allow theme generation. These qualitative data were used to gauge the effect of SIM on students' conceptual understanding.

3. Results and Discussion

This section presents and discusses the study's results in relation to the objectives.

3.1 Students' Level of Conceptual Understanding between the Experimental and Control Group (Post-Test)

Table 3: Raw Scores of Experimental and Control Group (Post-test)

Gain Score Ranges	Control Group			Experimental Group		
	f	%	ITP	f	%	ITP
14-15	0	0	O	2	9.09	O
13	0	0	P	2	9.09	P
12	0	0	AP	5	22.73	AP
11	0	0	D	5	22.73	D
10-0	22	100	B	8	36.36	B
Total (Mean)	**22**	**100**	**B (7.77)**	**22**	**100**	**D (11)**

Legend: ITP – Interpretation; O – Outstanding; P – Proficient; AP – Approaching Proficient; D – Developing; B – Beginning

Table 3 presents the raw scores of students after their exposure to the Strategic Intervention Material (SIM) and a conventional learning module. Results show that all students (100%) in the control group were categorized under the 'Beginning' level (score range: 0–10). In contrast, 9.09% (2 out of 22) of students in the experimental group reached the 'Outstanding' level (score range: 14–15). Additionally, a greater proportion of students in the experimental group were categorized at higher performance levels compared to the control group.

The control group obtained a mean score of 7.77, while the experimental group scored an average of 11. Although both groups exhibited relatively low conceptual understanding, the experimental group demonstrated higher achievement levels. This suggests that SIMs can support better conceptual learning than conventional instruction. According to the Department of Education (2016), SIMs are designed to address least-mastered competencies by providing structured, engaging, and student-friendly materials that supplement traditional instruction.

These findings are supported by educational research emphasizing the effectiveness of student-centered instructional strategies in promoting conceptual understanding, particularly in science education (Hmelo-Silver et al., 2007). The observed improvements among the experimental group align with the constructivist learning theory, which highlights the importance of active involvement in constructing knowledge (Vygotsky & Cole, 1978). While average performance remains at the developing level, the use of SIMs appears to have facilitated deeper learning and engagement, which are crucial for long-term academic success in science (National Research Council, 2000).

3.2 Interpretation and Comparison of Students' Conceptual Understanding (Posttest)

The posttest was a critical tool for evaluating the students' performance after their exposure to the learning materials in both the control and experimental groups.

Table 4: Interpretation of the Level of Conceptual Understanding of the Two Groups

Group	Overall Mean	Rating	Interpretation
Control	7.77	Below 75%	Beginning
Experimental	11	75% - 79%	Developing

As shown in Table 4, students in the control group had an overall mean score of 7.77, corresponding to a rating below 75%, which is interpreted as the 'Beginning' level of conceptual understanding. In contrast, the experimental group attained a mean score of 11, which corresponds to a rating between 75%–79%, classified as 'Developing.'

These results suggest that students exposed to the Strategic Intervention Material (SIM) achieved a higher level of conceptual understanding compared to those who received conventional instruction. This aligns with the objectives of the SIM, which is to address learning gaps in least-mastered competencies through interactive and learner-centered content (Department of Education, 2016).

The findings are also supported by evidence that active learning strategies and scaffolded materials promote better retention and understanding of scientific concepts than traditional lecture-based methods (Freeman et al., 2014). From a theoretical standpoint, this reflects Vygotsky's (1978) social constructivist theory, which emphasizes the role of mediated learning experiences and appropriate scaffolding within a learner's Zone of Proximal Development (ZPD) in enhancing understanding.

While the experimental group did not reach the highest mastery level, their performance suggests that SIMs contribute meaningfully to academic improvement and may serve as an effective intervention tool in science education (National Research Council, 2000).

3.3 Comparison of the Conceptual Understanding of the Two Groups (Post-Test)

Before comparing the significant difference in the achievement level of the two groups, the researcher ran a test of normality using the Kolmogorov-Smirnov test. Based on the results, the p-value for the scores under the control group is .002, which means that the distribution of the scores under this group is not normal. Therefore, the use of the Mann-Whitney test is appropriate.

Table 5: Comparison of the Level of Conceptual Understanding of Two Groups

Group	n	Std. Dev.	Test Used	Mann-Whitney U	p-value	Decision
Control	22	1.63	Mann-Whitney Test	47.500	.00001	Significant
Experimental	22	1.93				

* Significant at 0.05 level of significance.

Table 5 presents the result of the Mann-Whitney Test in testing the significant mean score difference of students' level of conceptual understanding between the control and experimental groups. Results revealed that the null hypothesis will be rejected since the computed p-value (.0001) is less than the significance level ($\alpha = 0.05$). Therefore, there is sufficient evidence to believe that the student's level of conceptual understanding is significantly different between the two groups.

This result aligns with earlier findings that SIMs are effective in improving academic performance in science by providing structured, engaging, and learner-centered materials (DepEd, 2016). Furthermore, this supports the principle that alternative assessment strategies and instructional interventions can lead to measurable improvements in students' conceptual understanding, particularly when conventional methods fall short (Prince, 2004; Freeman et al., 2014).

3.4 Field Notes

Following the activity, semi-structured interviews were conducted with students from both the control and experimental groups. Students using the conventional learning module expressed a lack of engagement and difficulty with the material. One student remarked, "There is nothing new to see in the module; it is boring and simple." Another admitted, "I don't know how to answer the DNA, mRNA, and the types of mutations." A third student noted, "So easy, just pairing letters, but identifying the amino acids and types is hard."

In contrast, students exposed to the Strategic Intervention Material (SIM) had more positive reactions. One student commented, "The design is beautiful; it looks fun and interesting." Another appreciated the simplicity of the tasks and said, "I find mutation an interesting topic because I now understand why there are Down syndrome and other disorders." However, some students suggested that the activities could be easier to understand with more examples, with one stating, "The activities are easy to understand if there are more examples provided before each activity to understand it better." Another student also mentioned, "It is hard to identify the amino acids, and I keep forgetting the pair of A, T, C, G."

The interviews revealed apparent differences in student engagement and understanding between the conventional learning module and the Strategic Intervention Material. While the conventional learning module failed to capture students' interest and presented challenges in comprehension, the SIM was well-received for its engaging design and relevant content. Despite some difficulties with specific concepts, students using the SIM showed greater interest and understanding of the topic.

4. Conclusion and Recommendations

The study aimed to determine if there is a significant difference in the conceptual understanding between the control and experimental groups. The results indicated that while the control and experimental groups exhibited low achievement levels, the experimental group demonstrated a higher average mean score (11) than the control group (7.77). This suggests that the SIM positively impacted students' conceptual understanding of mutations.

The significant difference in mean scores between the experimental and control groups, as evidenced by the Mann-Whitney Test, further supports the effect of SIM on students' conceptual understanding. Additionally, qualitative data from field notes highlighted that the students found the SIM more engaging and easier to understand than the conventional learning module. The findings suggest that SIM is a valuable instructional tool for improving the conceptual understanding of mutations among Grade 10 students.

To enhance the conceptual understanding of Grade 10 students, it is recommended that SIM be integrated into the regular biology curriculum. Moreover, research suggests implementing the SIM with enough time to improve further the students' conceptual understanding and retention of genetic concepts. Finally, SIM can be implemented for many students to ensure its effectiveness. By adopting these recommendations, educators can leverage the benefits of SIMs to foster deeper understanding of complex scientific concepts, thereby improving overall student achievement in biology.

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