Development and Evaluation of Educational Games Using Lumi Education in General Biology 1 for STEM Students: Basis for Recommended Supplementary Teaching Materials

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ABSTRACT

This study aimed to assess the perceived effectiveness of the educational games and the overall performance of the students after it was introduced to them. A descriptive-comparative method of research was utilized. Respondents of this study were twenty-six (26) Grade-12 STEM students. Researcher-made validated questionnaire based on a 5-point Likert scale was used for data collection. The findings of this study revealed that the contents used for educational games were about the cell cycle and cell membrane. Most Essential Learning Competencies were focused on describing, identifying, relating, and explaining biology contents. All of the educational games were rated strongly agree by the respondents. Students enjoyed the games and increased their motivation, interest, cooperation, and participation which transcribed better performance in class. Individual mean scores per lesson indicate that students fully understood the cell cycle concept: mitosis and meiosis. However, further interventions are needed to fully comprehend the function of the cell membrane components and transport mechanisms in the cell. Data analysis also shows a significant difference in the respondent's responses on the perceived effectiveness of educational games and their mean scores when grouped according to gender. On the other hand, there was no significant relationship between the perceived effectiveness of educational games and the performance of students. A proposed action plan was designed to further improve the effectiveness of educational games in enhancing students learning in General Biology 1. Also, the researcher recommends that teachers may try to develop their games using Lumi Education software.

INTRODUCTION

The novel coronavirus disease (COVID-19), later named SARS-CoV-2, was first reported in Wuhan City, China, in December 2019 (World Health Organization, 2020). It has become the world's foremost problem in just a few months, resulting in millions of deaths and a global economic recession. The COVID-19 outbreak has changed the lives of many people and the government sector. One of the sectors affected by this pandemic is the learning institution or education system.

The pandemic has brought tremendous changes to the educational system in the Philippines. Since March 2020, all public and private schools in basic education nationwide have decided to suspend or cancel in-person classes. This has changed the delivery of learning in the Department of Education (DepEd) and transitioned teachers' teaching approach from face-to-face to distance learning modalities. According to DepEd, the different types of distance learning modalities include Online Learning (OL), Modular Distance Learning (MDL), TV-Based Instruction, and Radio-Based Instruction (Llego, 2020). The emergence of the COVID-19 pandemic has increased the importance and potential of technology in education. Many activities can now be performed online. For instance, in education, online learning makes it possible for students to acquire knowledge without attending school. Similarly, teachers may no longer use blackboards and chalks because web conferencing is now an alternative. Educators can now create learning aid materials using various online software and applications. Since Face-to-Face classes are not possible, many teachers are forced to create learning materials that students can use at home. At that time, the most convenient and easiest way to connect with learners and parents was through social media and online learning platforms, such as Zoom and Google Classroom. Hence, teachers need to develop technology-based learning and teaching materials. Through these materials, teachers can ensure that students continue to learn, even without physical meetings. Undeniably, technology has played a vital role during the COVID-19 pandemic.

Technology has significantly contributed to the expansion of human knowledge. It simplifies complex matters and challenging tasks. Over time, technology has become increasingly sophisticated and contemporary. With the proliferation of commercial gadgets and high-speed Internet, people have become more dependent on technology. For example, children and adults use computers and mobile devices for entertainment, social media, web browsing, texting, and numerous other purposes.

Technology plays an indispensable role in an individual's daily life. Rapid technological development has led to the emergence of social networking sites and social media applications. Studies have shown that these applications have a significant impact on the interests of students. Moreover, educators view technology as an ally for providing quality education, as it can enhance students' understanding and academic performance.

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In this digital era, the majority of students are ICT-smart. Most of their activities, including their learning styles, are dominated by technology or ICT. Thus, it is imperative for teachers to integrate and use ICT in their teaching pedagogy as early as preschool (Dong, 2018).

Many studies have proven that Information Communication Technology (ICT) enables learners to learn better and more effectively. The integration of ICT into the teaching and learning process is highly effective for both teachers and students (Ghavifekr & Rosdy, 2015). ICT significantly affects students' cognitive achievement in vocational courses. This increases learners' motivation, collaboration, and interactivity (Fiandra et al., 2022). Motivated people learn more (Borghans et al., 2016). ICT use in the classroom is important for providing students with opportunities to learn and apply the required 21st-century skills (Ratheeswari, 2018). Technology has made learning enjoyable (Raja & Nagasubramani, 2018).

According to Fernández-Gutiérrez et al. (2020), the impact of ICT on educational outcomes depends on the subject and type of use. Therefore, policies aimed at increasing the educational use of ICT should be carefully evaluated to determine in which fields, uses, and methods can improve educational outcomes.

The Philippine government also values the importance of technology in education. Article XIV, Section 10 of the 1987 Philippine Constitution states: "Science and technology are essential for national development and progress. The State shall give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training, and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life."

Moreover, the Education Act of 1982, known as Batas Pambansa Blg. 232 stated that: "The teacher must sustain interest and enthusiasm in improving instruction so that he may be able to maximize the learning capabilities of his students. He must also be aware of the role of formal education where the government has made its policy to gear higher education towards the provision of quality education". With this cited information, the need to develop science- and technology-based teaching materials is vital to attain the government's goals of quality education for all Filipino learners. More enticing and enjoying educational games are also necessary to ensure that learning occurs even with little teacher supervision.

Carstens et al. (2021) noted that technology enhanced teaching and learning. With the proper use and implementation of educational technology in the classroom, students will undoubtedly increase their engagement and interest, leading to a more favorable environment for learning. On the one hand, technology could also be detrimental to learning. Hence, teachers in this situation must be wise in deciding what instructional materials should be developed and used to improve the teaching-learning process. Gouëdard et al. (2020) added

that, to attain such a goal, teachers must be given sufficient training and workshops on using ICT in teaching.

As the facilitator of learning, the teacher can significantly contribute to enhancing the student's academic performance. Ndayambaje et al. (2021) identified the factors in poor performance contributing to the student's poor performance in Biology subject. The results indicated that the root causes of students' poor performance in biology were English language as the medium of instruction, insufficient laboratory equipment, insufficient teaching and learning materials, inappropriate teaching methodology, amount of content and time allocated, inadequate involvement of parents in learners' education, poverty, students' absenteeism, and school environment. Hence, teachers must improve their teaching strategies and methodologies to suit their clienteles' needs.

Research Questions

This study's primary purpose is to develop and evaluate an educational game in General Biology 1 topics using Lumi Education software for Science, Technology, Engineering, and Mathematics students. Specifically, this study sought to answer the following questions:

1. What are the contents and Most Essential Learning Competencies (MELCs) used for educational games based on the following modules:
   a. Module 7 (Cell Division)
   b. Module 9 (Chromosomal Abnormalities)
   c. Module 10 (Cell Membrane Structure)
   d. Module 11 (Cell Membrane and Its Function)
   e. Module 12 (Transport Mechanism in Cell)?

2. a. How did the students perceive the effectiveness of the educational games?
   b. How did the students behave and react while using the educational games?

3. What are the mean scores of the students using educational games?

4. a. Is there a significant difference in the perceived effectiveness of educational games and the mean scores of students when they are grouped according to gender?
   b. Is there a significant relationship between the students' perceived effectiveness of educational games and students' performance?

5. What are ways to improve the effectiveness of educational games?

Research Hypothesis

Ho1: There is no significant difference in the perceived effectiveness of educational games and the mean scores of students when they are grouped according to gender.
Ho2: There is no significant relationship between the students' perceived effectiveness of educational games and students' performance.

LITERATURE REVIEW

John Dewey once penned: "If we teach today's students, as we taught yesterday's, we rob them of tomorrow." In this

digital era, the use of boring learning materials and teaching pedagogy in imparting knowledge will undoubtedly lead to students' poor academic performance. Therefore, some teachers who are reluctant to use technology might find it hard to sustain the engagement and participation of the students. This necessitates that modern educators evolve and modify their pedagogical practices to satisfy the needs of their classes.

The process of learning requires a variety of media support to help learners grasp and fully understand the lesson (Canale, 2012). Thus, instructional materials should be effective and tailored to the interests and needs of the students. Research shows that more engaged and active learning yields a higher gain in knowledge. One example of a more engaged and active teaching strategy is the use of gamified education or the use of educational games. Shrivastava (2021) stated that a sufficient number of studies demonstrate that gamifying the learning process can increase user engagement, user retention, and knowledge. A game can be a mental or physical activity that aims to entertain participants and provide them with rewards. Educational games, on the other hand, refer to all developed games with the intent of helping students learn specific skills. Zeng et al. (2020) defined educational games as software with an educational purpose that can create a realistic scene and motivate the learner. According to them, educational games make learning more interesting, promote learning by doing, and improve student abilities and skills. Educational games can make learning more scientific, enjoyable, and effective. Alonso-Fernandez et al. (2020) found that educational games could significantly improve student engagement, motivation, and learning outcomes.

Mohamad et al. (2018) categorized gaming into game-based learning, gamification, serious game, and simulation. Game-based learning refers to actual games in the classroom to enhance the teaching and learning experience. Gamification, on the one hand, refers to the use of game design elements in a non-game context. A serious game is designed for specific purposes to achieve something, while simulation games aim to simulate real-world things and are usually used in training.

Kangas et al. (2017) stressed that the integration of games in teaching is a relatively unexplored area of research despite the rising interest in educational games. Digital games increase students' engagement (Schindler et al., 2017). Fokides (2017) asserted that students taught mathematics concepts with digital games significantly performed better than other students. Studies have shown that game-based learning significantly improved the learning performance of students in Science (Sumandal, 2022), Mathematics (Wang et al., 2022), English (Wu, 2018), and other different curricula (Arcagok, 2021) as compared to traditional teaching approach.

The use of educational games in traditional teaching can enhance students' learning motivation and learning effects (Cheung & Ng, 2021), engagement and motivation (Lo & Miller, 2020), improve achievement, retention and cognitive (Selvi & Öztürk Çoşan, 2018). Yu et al. (2020) proposed game features that game designers should consider in designing game-based learning materials. This includes perceived usefulness, ease of use, and goal clarity, which could increase student engagement and improve the enjoyment of games.

Developing instructional materials requires a lot of thinking and decision-making. It needs careful planning and choosing appropriate material to use to ensure that learning materials are within the interest and levels of students. These developed instructional materials should also meet students' expected outcomes or competencies. Hence, creating teaching materials should be aligned with the curriculum standards that students can learn.

An educational game must align with learning outcomes and not be competitive in the conventional sense; it must achieve proper alignment with the curriculum, meet objectives and be fun (University of Toronto, 2022). Conversely, for educational games to be effective, Zirawaga et al. (2017) emphasized that educational games should be in line with the curriculum. Marklund (2013) suggested that educators working with game developers should be aware and knowledgeable of the subject matter. Motivating students will lead to successful learning (Perensky, 2001). One way of motivating children is to design educational tools that are as engaging and motivating as popular games (Nand et al., 2019). Thus, instructional materials like educational games should be appealing to the eyes of the students. Educational games should also be interactive.

Moreover, educational games should also promote different skills of students. Satrio et al. (2021) believed that game-based learning enhances students' creativity, critical thinking, and cognitive skills related to technology use. Carstens et al. (2021) also explain that teachers and students need more training to better implement technology in the classroom.

Many teachers have found it challenging to develop interactive learning materials because of some technicalities like programming and coding. Other compelling reasons include the cost of the software, time-consuming since it takes time to learn and design, which adds to cognitive loads and stress, and issues of access because it has to be connected to the internet (Marklund, 2013).

Initial readings have shown that educational games significantly improve students' performance compared to traditional teaching. Studies reviewed also show enough research on the development of games in teaching, considering their different types—game-based learning, gamified learning, serious games, and simulation games. However, according to the researcher's readings, Lumi Education is underutilized for developing educational games and interactive learning materials in the Philippines. At the time of this research, there were no published studies on games created with Lumi education software. With the extensive uses, benefits, and contributions of technology in people's lives, the researcher intends to

create an instructional design using the latest educational software to improve students' science performance.

Therefore, this study aims to develop and evaluate educational games in General Biology 1 topics for STEM students. With this, students will be able to comprehend biology lessons better interactively.

MATERIALS AND METHODS

Research Design

This study follows a mixed-method research design. A mixed methods research design is a procedure for collecting, analyzing, and "mixing" quantitative and qualitative research and methods in a single study to understand a research problem (Creswell, 2012). Mixed methods can help gain a more complete picture than a standalone quantitative or qualitative study, as it integrates the benefits of both methods (George, 2022). Research questions 2a, 3, and 4 were quantitative, while research questions 1 and 2b were qualitative.

The quantitative approach employed descriptive-comparative. Descriptive-comparative research studies contain (a) no manipulation of the predictor variable, (b) no random assignment to groups, and (c) a comparison group (Cantrell, 2011). A descriptive-comparative design was appropriate for the study because a nonexperimental causal-comparative design enabled the identification of the differences among the variables.

Sample

Respondents of this study were twenty-six (26) Grade 12 STEM students of Governor Alfredo M. Abueg Sr. National Technology, and Vocational Memorial High School enrolled during the 1st Semester of the School Year 2022-2023. Grade 12 STEM students purposively selected as the respondents of the study because they were the only Strand in SHS who was taking General Biology during the semester of School year 2022-2023.

The table below shows the breakdown of the number of respondents according to sex.

Grade 12 – Spinel Science, Technology, Engineering, and Mathematics Strand		
Male	Female	Total
4	22	26

Data Gathering Tools

To collect the needed data, the following instruments were used: (1) 8 different types of educational games anchored to the five (5) priority Most Essential Learning Competencies (MELCs). These educational games were incorporated into the activity portion of the lesson. Educational games have undergone evaluation by six science teachers and 2 ICT teachers. Revisions were made based on the suggestion of the teachers. (2) A researcher-made 5-point Likert Scale was also used to assess the games' effectiveness. The instrument was pilot-tested on 10 student respondents. Using Cronbach's Alpha, the reliability coefficient of this instrument was 0.86.

This means that the instrument is valid and reliable. The instrument was also checked by at least three panels of internal and external validators. (3) Checklist was utilized to determine the behavior and reaction of the students while using the games based on the recorded video. (4) Finally, the researcher employed a 5-item quiz in each learning content to measure the student's performance when educational games were introduced.

Data Gathering Procedure

Before conducting the research and data gathering, informed consent was secured and addressed to the respondents' parents. Respondents were appropriately dealt with, following the minimum health protocols ensuring that their health would not be compromised. They were also oriented that their participation in this study would benefit not only them but also the teachers and administrators of the school.

At the onset of data collection, the researcher identified the Content and Most Essential Learning Competencies (MELCs) that have not yet been attained in the subject General Biology 1 for the STEM strand. The researcher ensured that the developed games were related to the Content and Most Essential Learning Competencies (MELCs) as well as to the Self-Learning Module of the students. Games were carefully structured in such a way that they would motivate and engage learners. The behavioral settings of the game were revised and edited to ensure that it substantially achieved the ultimate purpose of the games – to enrich the student's learning experience. The educational games using Lumi Education software were developed for three (3) weeks. There was a total of eight (8) educational games created. These games were presented to two (2) science major teachers and one (1) ICT teachers to assess the games' content, feature, and applicability. Teacher evaluators were given two (2) days to evaluate the said games. After this, educational games will be revised based on the comments and suggestions of the Science and ICT teachers.

Before the beginning of the class, a game to be used for a specific lesson of the day was given or transferred to the tablet and android phones of the students. Each student has an individual gadget and a copy of the game. Students will be instructed not to play or open the game until required to do so. Games were played during the activity part based on the sequence of lessons in the Self-Learning Module and as indicated in the Weekly Learning Plan. Activities were in the group, but games were still individual. Class activities with the incorporation of educational games were recorded. Videos were used to monitor how the students performed or used the game. Using a checklist, the behavior and reactions of the students, as reflected in videos, were collected. Before the class ended, a five-item quiz, adopted from SLM, capturing the learning standards or learning competencies, was administered to assess the student's understanding of the lesson. This also served as the baseline for the researcher-teacher if the learning objectives were

met. More than ever, the scores of the students were analyzed to find out the student's performance with the use of developed educational games. After each of the games was integrated into the lesson as additional or supplementary learning materials to further enhance their understanding of the lesson, a self-made questionnaire which is a 5-point Likert scale was administered. Students were asked to rate the perceived effectiveness of these games in comprehending the lessons. An action plan on how to improve the developed educational games based on the findings of this study was crafted.

Data Analysis Procedure
In analyzing the gathered data, the researcher employed the following statistical treatment:
Mean was used to analyze the data about the perceived effectiveness of the educational games based on the 5-point Likert Scale instrument. Mean and Standard Deviation were used to describe the mean score of the students based on the 5-item quiz in every topic.
A T-test for an independent sample was used to determine if there would be a significant difference in the perceived effectiveness of educational games and mean scores of students when respondents were grouped according to gender. Furthermore, regression analysis was used to establish a relationship or association between 2 variables. It was utilized to assess the strength of the relationship between variables and for modeling the future relationship between them. In this study, the students' perceived effectiveness of educational games and students' performance will be correlated.

No statistical tool was used about the questions content and Most Essential Learning Competencies (MELCs) used in educational games as well as on the observed behavior and reactions of the students while using the educational games. These questions fall under the qualitative method. A qualitative analysis was used instead.

RESULTS AND DISCUSSION
1. What are the contents and Most Essential Learning Competencies (MELCs) used for educational games based on the following modules:
   a. Module 7 (Cell Division)
   b. Module 9 (Chromosomal Abnormalities)
   c. Module 10 (Cell Membrane Structure)
   d. Module 11 (Cell Membrane and Its Function)
   e. Module 12 (Transport Mechanism in Cell)?
Table 1 shows the identified contents and Most Essential

Table 1: Contents and MELCs used in Educational Games

Content	Most Essential Learning Competencies
Mitosis and Meiosis	Describe the stages of mitosis and meiosis given 2n=6 (STEM_BIO 11/12-Id-f-7)
Chromosomal Diseases and Disorders	Identify disorders and diseases that result from the malfunction of the cell during the cell cycle (STEM_BIO 11/12-Id-f-10)
Structural Components of the Cell Membrane	Describe the structural components of the cell membrane (STEM_BIO 11/12-Ig-h-11)
Functions of Structural Component of Cell Membrane	Relate the structure and composition of the cell membrane to its function (STEM_BIO 11/12-Ig-h-12)
Transport Mechanism in Cell	Explain transport mechanism in cells (diffusion, osmosis, facilitated transport, active transport) (STEM_BIO 11/12-Ig-h-13)

Learning Competencies in General Biology 1, which was used as the basis for developing educational games. The content was primarily divided into two major biology concepts: cell cycle and cell membrane. The cell cycle includes lessons about mitosis, meiosis, and chromosomal abnormalities during cell division. On the other hand, cell membrane lessons discuss the structure of the cell membrane, the functions of the structure of the cell membrane, and the transport mechanisms that occur within the cell membrane. Furthermore, the Most Essential Learning Competencies (MELCs) focus on enriching students' understanding through describing, identifying, relating, and explaining the content.

2. a. How did the students perceive the effectiveness of the educational games?
   b. How did the students behave and react while using

Table 2: Perceived Effectiveness of Educational Games 1, 2, and 3 (Image Sequencing, Crossword Puzzle, and Drag & Drop) N = 26

Indicative Statement	Mean	Result Interpretation
Educational games helped me to better understand the lessons in Biology.	4.50	Strongly Agree
Educational games made my learning of lessons fun and exciting.	4.50	Strongly Agree
Educational games enhanced my memory skills in the lessons discussed.	4.46	Strongly Agree
Educational games were an effective way of learning biology concepts.	4.42	Strongly Agree
Educational games improved my critical thinking skills.	4.42	Strongly Agree
Educational games contributed to an easy understanding of difficult lessons in Biology.	4.38	Strongly Agree
Educational games motivated me to attend and participate in class.	4.38	Strongly Agree

Educational games allowed me to interact with my classmates.	4.35	Strongly Agree
Educational games allowed me to build harmonious interactions with my teachers.	4.23	Strongly Agree
Educational games reduced my anxiety about my teachers.	4.19	Agree
Overall Mean	**4.38**	**Strongly Agree**

Legend: 4.2-5.00-Strongly Agree; 3.40-4.19-Agree; 2.60-3.39-Neutral/Undecided; 1.80-2.59-Disagree; 1-1.79-Strongly Disagree

the educational games? Table 2 presents the perceived effectiveness of educational games such as Image Sequencing, Crossword Puzzles, and Drag and Drop in General Biology 1 class. Based on the results presented above, the Grade 12 STEM students rated the educational games with an overall mean score of 4.38 with a strongly agree descriptive result. Furthermore, the analysis shows that statements like "educational games helped me better understand the lessons in Biology" and "educational games made my learning fun and exciting" received the highest mean score of 4.50. To summarize, the developed educational games improved student understanding and made biology class more enjoyable and exciting. This

result is consistent with Selvi & Öztürk Çoşan (2018) findings that educational games improve achievement, retention, and cognition. Zeng et al. (2020) found that educational games can make learning more scientific, enjoyable, and effective.

However, the statement "educational games reduced my anxiety about my teachers" has the lowest mean, with a mean score of 4.19, which falls under the agree category. This indicates that educational games were ineffective in reducing the students' anxiety about their teacher. This implies that the teacher should modify his teaching methods and develop new ways to engage students.

Table 3 explains the perceived effectiveness of Flashcards

Table 3: Perceived Effectiveness of Educational Games 4 (Flashcard) N = 26

Indicative Statement	Mean	Result Interpretation
Educational games helped me to better understand the lessons in Biology.	4.46	Strongly Agree
Educational games allowed me to interact with my classmates.	4.46	Strongly Agree
Educational games allowed me to build harmonious interactions with my teachers.	4.35	Strongly Agree
Educational games made my learning of lessons fun and exciting.	4.31	Strongly Agree
Educational games were an effective way of learning biology concepts.	4.31	Strongly Agree
Educational games reduced my anxiety about my teachers.	4.25	Strongly Agree
Educational games contributed to an easy understanding of difficult lessons in Biology.	4.19	Agree
Educational games motivated me to attend and participate in class.	4.19	Agree
Educational games enhanced my memory skills in the lessons discussed.	4.19	Agree
Educational games improved my critical thinking skills.	4.15	Agree
Overall Mean	**4.29**	**Strongly Agree**

Legend: 4.2-5.00-Strongly Agree; 3.40-4.19-Agree; 2.60-3.39-Neutral/Undecided; 1.80-2.59-Disagree; 1-1.79-Strongly Disagree

as an educational game. Respondents scored this game with an overall mean of 4.29, which can be interpreted as strongly agree. This suggests that Flashcards as supplementary teaching material is effective in General Biology classes.

Based on the analysis, four (4) indicative statements received the lowest mean score. These indicators are: "educational games contributed to an easy understanding of difficult lessons in Biology", "educational games motivated me to attend and participate in class", and "educational games enhanced my memory skills in the

lessons discussed." All these three statements have the same mean score of 4.19. In addition, the statement "educational games improved my critical thinking skills" has a mean score of 4.15. Students rate these statements as agree. This entails that the re-development of this educational game should focus on content that will help learners to understand the lesson fully and can improve learners' higher-order thinking skills.

Table 4 depicts a summary of the perceived effectiveness of Drag and Drop as an educational game. Data revealed that respondents strongly agreed that Drag and Drop

Table 4: Perceived Effectiveness of Educational Games 5 (Drag and Drop) N = 26

Indicative Statement	Mean	Result Interpretation
Educational games allowed me to interact with my classmates.	4.54	Strongly Agree
Educational games were an effective way of learning biology concepts.	4.46	Strongly Agree
Educational games enhanced my memory skills in the lessons discussed.	4.42	Strongly Agree
Educational games helped me to better understand the lessons in Biology.	4.38	Strongly Agree
Educational games contributed to an easy understanding of difficult lessons in Biology.	4.35	Strongly Agree
Educational games motivated me to attend and participate in class.	4.31	Strongly Agree
Educational games made my learning of lessons fun and exciting.	4.27	Strongly Agree
Educational games reduced my anxiety about my teachers.	4.23	Strongly Agree
Educational games allowed me to build harmonious interactions with my teachers.	4.23	Strongly Agree
Educational games improved my critical thinking skills.	4.19	Agree
Overall Mean	**4.34**	**Strongly Agree**

effectively enhanced students' understanding of the lesson and improved their social and thinking skills. With a strongly agreed adjectival representation, this educational game received an overall mean rating of 4.34. Moreover, a mean score of 4.19 was the lowest reported mean score for improving students' critical thinking skills. As a result, enhancements to the game should focus on features that can help students improve their critical thinking skills. Table 5 entails how the students perceived the effectiveness of Memory and Fill in the Blanks educational games in General Biology class. Based on the result, respondents strongly agree that these games are undeniably effective in teaching students of biology lessons, with an overall mean score of 4.39. On the other hand, the lowest mean score was about reducing students' anxiety toward their teacher with a numerical value of 4.19, which falls under agreed result interpretation. This manifests that games still need improvement to overcome the students' anxiety

Table 5: Perceived Effectiveness of Educational Games 6 and 7 (Memory Game and Fill in the Blanks) N = 26

Indicative Statement	Mean	Result Interpretation
Educational games made my learning of lessons fun and exciting.	4.58	Strongly Agree
Educational games were an effective way of learning biology concepts.	4.58	Strongly Agree
Educational games helped me to better understand the lessons in Biology.	4.50	Strongly Agree
Educational games allowed me to interact with my classmates.	4.46	Strongly Agree
Educational games motivated me to attend and participate in class.	4.42	Strongly Agree
Educational games contributed to an easy understanding of difficult lessons in Biology.	4.35	Strongly Agree
Educational games enhanced my memory skills in the lessons discussed.	4.35	Strongly Agree
Educational games allowed me to build harmonious interactions with my teachers.	4.27	Strongly Agree
Educational games improved my critical thinking skills.	4.19	Strongly Agree
Educational games reduced my anxiety about my teachers.	4.19	Agree
Overall Mean	**4.39**	**Strongly Agree**

Legend: 4.2-5.00-Strongly Agree; 3.40-4.19-Agree; 2.60-3.39-Neutral/Undecided; 1.80-2.59-Disagree; 1-1.79-Strongly Disagree

about their teacher.

Table 6 presents the students' perceived effectiveness of the educational game Single Choice Set. It can be gleaned that respondents rated it with an overall mean rating of 4.45, interpreted as strongly agree. This means that most students believed that the Single Choice Set game was very effective in learning biology concepts. This also connotes that this educational game helps enhance students' understanding of the lesson and improves learning skills such as higher-order thinking and socialization skills.

Table 6: Perceived Effectiveness of Educational Games 8 (Single Choice Set) N = 26

Indicative Statement	Mean	Result Interpretation
Educational games allowed me to interact with my classmates.	4.58	Strongly Agree
Educational games helped me to better understand the lessons in Biology.	4.54	Strongly Agree
Educational games made my learning of lessons fun and exciting.	4.50	Strongly Agree
Educational games were an effective way of learning biology concepts.	4.50	Strongly Agree
Educational games enhanced my memory skills in the lessons discussed.	4.50	Strongly Agree
Educational games motivated me to attend and participate in class.	4.42	Strongly Agree
Educational games allowed me to build harmonious interactions with my teachers.	4.42	Strongly Agree
Educational games contributed to an easy understanding of difficult lessons in Biology.	4.38	Strongly Agree
Educational games improved my critical thinking skills.	4.31	Strongly Agree
Educational games reduced my anxiety about my teachers.	4.31	Strongly Agree
Overall Mean	**4.45**	**Strongly Agree**

Legend: 4.2-5.00-Strongly Agree; 3.40-4.19-Agree; 2.60-3.39-Neutral/Undecided; 1.80-2.59-Disagree; 1-1.79-Strongly Disagree

Table 7 illustrates the observed behavior and reactions of the students while using the developed educational games. In general, students exemplified positive behavior and reactions toward the game. Hence, educational games are an effective tool to enforce enjoyment, motivation, cooperation, interest, and active class participation. This

Table 7: Students' Behavior and Reactions During the Used of Educational Games

Educational Games	Students' Behavior and Reaction
Game 1 - Mitosis (Image Sequencing)	Positive Behavior and Reaction
Game 2 - Mitosis (Crossword Puzzle)	Enjoyed the game
Game 3 - Meiosis (Drag and Drop)	Motivated
Game 4 - Chromosomal Abnormalities (Flashcard)	Cooperative
Game 5 - Structure of Cell Membrane (Drag and Drop)	Active and participative
Game 6 - Function of the Components of Cell Membrane (Memory Game)	Interested
Game 7 - Function of the Components of Cell Membrane (Fill in the Blanks)	Negative Behavior and Reactions
Game 8 - Transport Mechanism (Single Choice Set)	Students have difficulty accomplishing some of the games.

finding confirms that using educational games in traditional teaching can enhance students' learning motivation and learning effects (Cheung & Ng, 2021), engagement, and motivation (Lo & Miller, 2020). However, the developer of the game should consider decreasing the difficulty of the game for students to accomplish the task.

Table 8 presents the mean score of students for every content or lesson where educational games were introduced. The mean scores of the students show that the topic Cell Cycle: Mitosis and Meiosis was the easiest since students' scores obtained a mean of 4.62 with a qualitative description of Outstanding. Furthermore, a

Table 8: Mean Score of Students N = 26

Content	Mean Score	sd	Qualitative Description
Cell Cycle (Mitosis and Meiosis)	4.62	0.49	Outstanding
Chromosomal Abnormalities	3.73	0.90	VerySatisfactory
Structure of Cell Membrane	3.96	0.76	VerySatisfactory
Function of the Components of the Cell Membrane	2.62	0.49	Satisfactory
Transport Mechanism in Cell	2.62	0.88	Satisfactory

Legend: 4.2-5.00-Outstanding; 3.40-4.19-Very Satisfactory; 2.60-3.39-Satisfactory; 1.80-2.59-Fairly Satisfactory; 1-1.79-Poor

standard deviation of 0.49 indicates that students' scores are clustered around the mean that manifest a good performance. Meanwhile, topics about Functions of the Cell Membrane Components and Transport Mechanism in Cell were the hardest since they both have a mean score of 2.62, which can be interpreted as satisfactory. Thus, the result suggests that teachers should provide additional intervention to the two (2) topics that gained

the lowest mean score, such as enrichment activities to enhance students' understanding of the lessons further.

4. a. Is there a significant difference in the perceived effectiveness of educational games and the mean scores of students when they are grouped according to gender?

b. Is there a significant relationship between the students' perceived effectiveness of educational games and students' performance?

Table 8: Differences in Perceived Effectiveness and Mean Scores N=26

Content	Sex	Perceived Effectiveness	Mean Score	T-test	P-value	Interpretation
Cell Cycle (Mitosis and Meiosis)	Male	4.13	5.00	4.531	0.010**	Significant
	Female	4.43	4.55	0.675	0.253	Not Significant
Chromosomal Abnormalities	Male	4.55	3.00	-2.233	0.055**	Significant
	Female	4.24	3.73	-2.222	0.018**	Significant
Structure of Cell Membrane	Male	4.03	5.00	0.229	0.416	Not Significant
	Female	4.40	3.91	-3.491	0.001**	Significant
Function of the Components of the Cell Membrane	Male	4.45	3.00	-7.487	0.002**	Significant
	Female	4.38	2.55	-14.446	0.000**	Significant
Transport Mechanism in Cell	Male	4.50	2.00	-5.470	0.006**	Significant
	Female	4.44	2.68	-9.693	0.000**	Significant

*Legend: **Significant at 0.05 level of significance, mcritical value = 2.079*

After performing the t-test: Paired Two Sample for Mean (Paired t-test) in a two-tailed test, it was found that most of the computed t-value are greater than the mcritical value of 2.079. However, the calculated t-value of the female respondents on the lesson cell cycle: mitosis and meiosis as well as male respondents on the cell membrane topic structure were lower than the mcritical value.

Similarly, it can be noted that except for the two previously mentioned lower t-value than the mcritical value, all of the computed p-values are less than 0.05, therefore, rejecting the null hypothesis. Hence, it can be concluded that in

most lessons, the perceived effectiveness of educational games and the mean scores of students are statistically significant when respondents are grouped according to their gender. In other words, there is overwhelming evidence that a gain score taken place in students' mean scores as a result of the use of educational games.

As shown in Table 9 it can be observed that the majority of the computed p-values were all greater than the level of significance of 0.05. These indicate no significant relationship between the perceived effectiveness of using educational games and the students' mean scores.

Table 9: Relationship of Perceived Effectiveness vs. Students' Performance N = 26

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5
Game 1	0.50	0.41	0.02	0.15	0.07
Correlation	0.009	0.03	0.91	0.47	0.73
p-value	Reject Null	Reject Null	Accept Null	Accept Null	Accept Null
Interpretation	Hypothesis	Hypothesis	Hypothesis	Hypothesis	Hypothesis

Game 2	0.60	0.02	0.04	0.27	0.01
Correlation	0.10	0.89	0.81	0.18	0.95
p-value	Accept Null	Accept Null	Accept Null	Accept Null	Accept Null
Interpretation	Hypothesis	Hypothesis	Hypothesis	Hypothesis	Hypothesis
Game 3	0.02	0.13	0.20	0.06	0.02
Correlation	0.91	0.54	0.33	0.76	0.91
p-value	Accept Null	Accept Null	Accept Null	Accept Null	Accept Null
Interpretation	Hypothesis	Hypothesis	Hypothesis	Hypothesis	Hypothesis
Game 4	0.04	0.11	0.12	0.07	0.34
Correlation	0.83	0.60	0.55	0.74	0.04
p-value	Accept Null	Accept Null	Accept Null	Accept Null	Accept Null
Interpretation	Hypothesis	Hypothesis	Hypothesis	Hypothesis	Hypothesis
Game 5	0.15	0.27	0.10	0.01	0.34
Correlation	0.44	0.18	0.63	0.95	0.10
p-value					
Interpretation					
	Accept Null	Accept Null	Accept Null	Accept Null	Accept Null
	Hypothesis	Hypothesis	Hypothesis	Hypothesis	Hypothesis

*Legend: **Significant at 0.05 level of significance*

However, only the perceived effectiveness of using educational games (Game 1) has a positive and significant relationship to respondents' mean scores in Quiz 1 ($rs=0.50$; $p< 0.009$) and Quiz 2 ($rs=0.41$; $p<0.03$). It can be concluded that Game 1 significantly improved the student's performance in Quiz 1 and 2. The finding of this study confirms that educational games help improve students' learning experience (Cheung & Ng, 2021).

Table 10: Proposed Action Plan for the Improvement of Educational Games

Area (s) and Project Title	Objectives	Person (s) Responsible	Activities	Time Frame	Expected Output
A Workshop on Developing Educational Games Using Lumi Education	To update teachers on new applications and software for creating interactive teaching materials	Researcher	Conduct School Learning Action Cell (SLAC) focusing on new ways to develop teaching materials (e.g., Lumi Education)	Year Round	Upgrade and upskill Filipino teachers with world-class skills in educational technology.
Game Developer Partnership	To enhance the features and workability of educational games	Researcher Programmer	Coordinate with game developer experts like animators and programmers and discuss how the developed educational games could be improved in terms of their features and workability.	Year Round	An enhanced version of developed educational games. Quality and updated versions of games
Building Up Connections	To get additional feedback and recommendations from science experts on the content of educational games	Researcher Science Master Teacher Science Supervisor	Invite Science Master Teachers or Science Supervisors to evaluate the educational games. Ask these pool experts to provide feedback or suggestions in terms of its content, level of difficulty, and alignment.	Year Round	Educational games will have consistent and accurate content. Quality-assured educational games
Two Heads are Better than One	To conduct further study on the evaluation of educational games using Lumi Education	Researcher Co-Teacher	Encourage co-teachers to conduct a similar study to increase its reliability and credibility.	Year Round	Validated and up-to-date research findings about educational games

CONCLUSIONS

1. Contents used for educational games were about the cell cycle and cell membrane. Most Essential Learning Competencies focus on describing, identifying, relating, and explaining biology contents or concepts.

2. All of the educational games were rated strongly agree by the respondents. It manifests that students perceived the educational games positively and thus helped them understand and comprehend the lessons in General Biology 1. Similarly, students enjoyed the game. Furthermore, it increased the students' motivation, interest, cooperation, and participation which transcribed better performance in class.

3. Individual mean scores per lesson indicate that students fully understood the cell cycle concept: mitosis and meiosis. Students also show very satisfactory performance in Chromosomal abnormalities and cell membrane structure. Further interventions are needed to fully comprehend the function of the cell membrane components and transport mechanisms in the cell.

4. There was a significant difference in the respondent's responses on the perceived effectiveness of educational games and their mean scores when grouped according to gender. On the other hand, there was no significant relationship between the perceived effectiveness of educational games and the performance of students.

5. The action plan was conceptualized to further improve the effectiveness of educational games in enhancing students learning in General Biology 1. The action plan focuses on leveling up the games' features and checking the content's internal consistency and validity.

RECOMMENDATION

1. Teachers may try to develop their games using Lumi Education software.

2. Teachers may employ educational games using Lumi Education as supplementary teaching material since it was found to be effective.

3. The non-techy teachers may consider collaboration with ICT or game developers such as programmers and animators.

4. School administrators may utilize Lumi Education as a training or workshop topic in an In-Service Training (INSET) to update and encourage teachers in new tools for developing teaching materials.

5. Future researchers may conduct this study again with a larger sample; the result might be improved compared to the existing research. Consider employing this study in other learning areas such as Math, English, and Social Studies.

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