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A Game-Based Learning Material for Developing Students' Conceptual Understanding of Photosynthesis

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Abstract

Game-based learning refers to creating a learning environment that integrates games which could be digital or non-digital to develop students' knowledge and skills acquisition. Several literature reviews of game-based learning have been studied both in sciences and other fields of studies such as mathematics, language, history and physical education. In this study the researcher developed a board game with the aim of enhancing students' conceptual understanding in photosynthesis. Board games encourage a positive environment among the players thus allowing them to work together to achieve the same goal (Dewar, 2023). Based on the overall evaluation of the developed board game, it obtained a satisfactory assessment in terms of design and creativity, which was evaluated by the in-service science teachers from Napolan, Pagadian City. The perception of the pre-service teachers and two sections of students from the ninth grade also obtained a satisfactory result. The performance of the students after the integration has a normalized gain divided into low and medium. Thus, those who belong to the lower normalized gain have implied less or no improvement after the integration. On the other hand, those who belong to the medium normalized gain have shown improvement after the integration of the board game.

Keywords: Game Based Learning, boardgame, photosynthesis

1. Introduction

The modernization of strategies used for classroom instruction is by no means a new phenomenon in the field of teaching. Digital or non-digital, the educational systems have now made an advancement in order to provide quality education to young learners. Card games and board games are now integrated in educational context for the purpose of learning and development (Homer, Kinzer & Plass, 2015). Studies have supported that games can be a great means of instruction to improve young learner's engagement and understanding (Tamosevicius, 2022).

Board games as a learning tool has gained attraction in the world of education now. Regardless of its familiarity, it's evident that most board games are created for young learners. Thus, it's important to develop one that would match the level of understanding of the learners, especially the ones in the higher level of learning. Studies have shown that board games enhances both hands-on and heads- on skill and knowledge development for all ages (Treher, 2010). According to the study of Eriksson (2021), board games significantly increase cooperative behavior among students consequently decreasing student's aggressive behavior. Henceforth, the researcher of study will specifically develop a board game that would enhance students conceptual understanding in Photosynthesis.

Another study has developed a board game as an instructional material in the field of teaching history. The result has presented that using board game as a game-based learning material in the learning instruction can enhance student potential in acquiring knowledge. In addition, such playful approach has given freedom to all processes of teaching and learning thus creating collective, collaborative and creative learning based to the students (Rajkovc et al., 2017).

In the Philippines, the Department of Education has made a partnership with Microsoft Philippines last April 28 2022, allowing learners, teachers and parents involvement in a new learning experience using a game-based learning called Minecraft Education Edition (DepEd, 2022). This tool is designed to make classroom experience more accessible and convenient to both the learners and the teachers. Undoubtedly, this has been a great start for the Philippines in improving our classroom instructions.

A study has revealed that compared to other countries; Philippines is behind in terms of quality education particularly in science subjects (Millanes, 2019). According to World Economic Forum, Philippines just ranked 70th out of 144 participating countries (Schwab, 2016). Low mastery of content knowledge has become one of the common problems that science students faced specifically in learning biology. The chosen focus of the study is about photosynthesis.

In addition, another study has characterized photosynthesis as a difficult topic in biology (Lim & Poo, 2021). There's been a lot of studies which can support the notion. A study conducted by Marmaroti (2006) found that students have a lot of conceptual misconceptions when it comes to photosynthesis and the occurrence of this problem can greatly affect students understanding as they go to a more advanced concept because photosynthesis is one of the foundations in understanding more biological processes.

With this study, learners would then be able to realize that there are various ways to acquire a certain concept. Through the use of novel teaching techniques, their interest will be stimulated, which may result in a shift in how they view learning towards scientific topics. Parents would therefore be encouraged to make a greater effort to assist their children's learning by taking care of their needs in the future. Furthermore, not just their child but most importantly their child's future will gain from this. Teachers would then learn new strategies and techniques for classroom instruction. The integration will be the way to bridge the generation gap among teachers and students. Furthermore, the learning process will be enjoyable. The administrator would then encourage teachers to attend more in service training, to learn more strategies to apply inside the classroom. With that, both student and the school's performance will gradually improve. This integration may generate additional researches and creations that will benefit the community in the future. The researcher would determine the effectiveness of the developed board game after finishing the study. They will therefore be aware of the advantages and disadvantages of the integration, which will serve as the foundation for board game development.

2. Methodology

2.1 Research Design

The researcher sought to develop a board game using the developmental research design and a quasi-experimental method research which covers both quantitative and qualitative methods of research. Developmental research design is defined as the systematic study of designing, developing, and evaluating a developed material. Back and Hwang (2005) stated that quasi-experimental method research aims to integrate and evaluate the educational intervention that's utilized as part of the classroom instruction. The quantitative data was obtained from the ratings of the evaluators of the boardgame, students' scores in the pre-test and post-test. The game-based learning material was evaluated through a rubric by experts, in-service teachers, and pre-service teachers. On the contrary, the qualitative data was obtained from the comments and suggestions of the evaluators from the face validation and perceptions gathered from an open-ended survey questionnaire.

2.2 Research Participants and Environment

Purposive sampling was used to select respondents for this study. Before the development of the study, the researcher interviewed twenty (20) in-service science teachers and thirty (30) Grade- 10 students. The data gathered here was the basis for the development of the game-based learning material and the chosen topic to focus on the board game. In addition, part of the survey analyzes how in-service teachers usually discuss the topics listed in the first quarter specifically on photosynthesis.

The try-out was played by twenty-six (26) pre-service teachers who were in enrolled in Bachelor of Secondary Education Major in Biology while thirty-six (36) Grade 9 students who were enrolled in the Special Program in the Arts for the pilot testing. Furthermore, thirty-seven (37) Grade 9 students from the Basic Education Program took part during the final implementation. The Grade 9 students for the pilot testing and final implementation were from the chosen school in Napolan, a barangay in the city of Pagadian, in the province of Zamboanga del Sur who's enrolled in the academic year 2023-2024.

After every implementation, comments and suggestion were given by the pre-service teachers, Grade 9 students and the in-service teachers. Both pilot testing and final implementation was in a public school in Napolan, a barangay in the city of Pagadian, in the province of Zamboanga del Sur, however the integration of the game-based learning material was conducted from two different sections which was chosen by the school.

2.3 Research Instruments

2.3.1 Perceived Difficulty on Grade 9 Science first quarter Topics Survey Questionnaires

The researcher created a learning needs assessment survey. The survey included the list of topics as presented in the K-12 DepEd Curriculum and MELCs. In-service teachers and Grade 10 students rated their level of understanding using a Likert Scale, very-easy to very difficult. The second part of the survey varies. For teachers, the questions include their usual practice on how they teach the listed topics and how they plan to teach the listed topics. For students, the questions were focused on how they want the listed topics to be discussed. Lastly both teachers and students chose how familiar they are with the list of boardgames. However, a follow up question was given to the teachers to support the result of the learning needs assessment from the students

2.3.2 Technical Reading and Writing Using Board Games Rubric

The researcher adopted a rubric in evaluating the developed board game from ReadWriteThink Lesson. The evaluation of the board game was divided into five factors: design and creativity, question cards, format and purpose, directions and content and difficulty. Each factors have distinctive components to evaluate thoroughly the developed game-based learning material. This was then rated accordingly from very satisfactory to not satisfactory.

2.3.3 Achievement Test in Science

A standardized test determined the students conceptual understanding in photosynthesis. The test items were based on DepEd Modules, Teacher's Guides and textbooks availability in science. The following learning competencies served as the guide in with regards to the content of the assessment test. Lastly, the questionnaire was evaluated by the thesis adviser and science teachers.

2.4 Data Gathering Procedure

This study used the Multimedia Development Model of Luther. This model consists of six stages, such as concept, design, material collection, assembly, testing, and distribution. The first stage is concept; in this phase, the pre-assessment planning was done by the researcher. The second stage is design; in this phase, the design of the board game and the gathering of suggestions from teachers were collected. The third stage is material collection; this phase concludes the gathering of materials needed for the development. The fourth stage is assembly; this phase starts with the development of the board game, face validation, and revisions. The fifth stage is testing; the try-out play, which was conducted by the preservice teachers, was done in this phase, as were the evaluation, pilot testing, and revision. The sixth stage is distribution; this is where the actual implementation, evaluation from students and in-service teachers, and identification of the perceptions of the students toward the board game are conducted.

2.5 Data Analysis

2.5.1 Mean

Mean determined the average scores from the following factors. First, in order to assess whether conceptual understanding of photosynthesis has improved, both scores from pre-test and post-test were analyzed. Second, the average scores from the evaluation of the rubrics from the in-service teachers and Grade 9 perceived the usefulness of the game-based learning material. The learning needs assessment was interpreted on five scales while the respondent's perception was interpreted on four scales.

Table 1. Interpretation of Data for Needs Assessment

Range	Verbal Interpretation
1.00 – 1.80	Very Easy
1.81 – 2.60	Easy
2.61 – 3.40	Fair
3.41 – 4.20	Difficult
4.21 – 5.00	Very Difficult

Table 2. Interpretation of Data for Respondents Perception

Range	Verbal Interpretation
1.00 – 1.75	Strongly Agree
1.76 – 2.50	Agree
2.51 – 3.25	Disagree
3.26 – 4.00	Strongly Disagree

2.5.2 Flesch-Kincaid Readability Test

The Flesh-Kincaid Readability Test was used by the researcher for both the pre-test and post-test. Rudolf Flesch and J. developed this readability test. Paul Kincaid Reading cases and Grade-level cases serve as the test's foundation. Low scores indicate test's text is challenging to understand.

2.5.3 Wilconxon Signed- Rank Test

The study incorporated a purposive sampling for the respondents of the study; thus, a nonparametric test was administered. The paired sample Wilcoxon test or also known as Wilcoxon signed rank test is a non-parametric alternative test used to compare two related samples, matched samples, or to conduct a paired difference test of repeated measurements on a single sample to assess whether their population mean ranks differ. In this study's case, the conceptual understanding of the students after the integration was measured from the pre-test and post-test scores.

2.5.4 Coding of the Data

The researcher used codes to interpret data. TA is for thesis adviser, T1 to T6 indicates the in-service teacher who took part during the evaluation of the board game. PS1-PS26 indicates the pre-service teachers from Bachelor of Secondary Education Major in Biology who participated during the try-out play. PT1-PT36 indicates the Grade 9 students from the Special Program in the Arts who participated during the pilot testing. Lastly, FI1-FI34 indicates the Grade 9 students from the Basic Education Program who participated during the final implementation.

3. Results and Discussion

3.1 Design and Development

Figure 1: Board game Prototype I

The figure shows board game prototype 1 after the comments and suggestions from the panel members and the thesis adviser. The design of the game was based on the storyline created which has a relation to the topic photosynthesis. The board game's concept is related to the snake and ladder. Thus, plant vines were employed in place of ladders and combustion indicators in place of snakes because the study's main focus is photosynthesis. The researcher made changes to the design by incorporating images that are essential to the process of photosynthesis as well as elements that would make the board game fitted to the storyline which is a small town. This board game was used during the try-out play. After the implementation the pre-service teachers gave some feedbacks that would enhance the board game more.

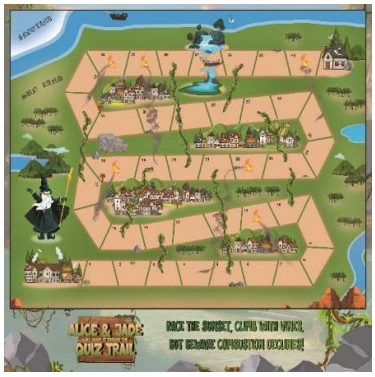

Figure 2: Board Game Prototype II

The figure shows the board game prototype II after the comments and suggestions from the pre-service biology teachers. The design of the game was based on the storyline created which has a relation to the topic photosynthesis. This board game was used during the pilot testing. Following the comments and suggestions, the researcher made improvements to the board game's design, gameplay, and question cards. The size of the board game was made bigger. The time allotted in answering the questions from the question cards were shorten into thirty (30) seconds. The researcher incorporated graphics and designs that correlates to the topic Photosynthesis. After the implementation, the Grade 9 students gave some feedbacks that would enhance the board game more.

Figure 3: Board game Prototype III

The figure shows the board game prototype III upon the comments and suggestions from the Grade 9 students. The design of the game was based on the storyline created which has a relation to the topic photosynthesis. This board game was used during the final implementation. In order to make the board game appropriate for ninth-Grade students and fits within a 60-minute class period, the researcher made revisions. Details that might influence students' interest in playing the game were also included by the researcher.

3.2 Evaluation of the developed board game

After completing the development of the board game, the board game was evaluated by six (6) in-service teachers who were majoring in science. These evaluators were also present during the final implementation of the research. The evaluators were chosen in connection with their expertise in learning science. The evaluators were five science teachers and one head teacher in science. They utilized the adapted rubrics for the evaluation of the board game. The rubrics is composed of five primary categories: Design and Creativity, Questions, Formal and Purposed, Directions and Content, and Difficulty. In this phase, six (6) in-service science teachers expressed their perceived usefulness towards the board game. Three open-ended questions were included in the survey, and these are some the comments of the in-service science teachers in Napolan, Pagadian City.

Table 3. Evaluation of the in-service science teachers on board game after final

Category	Panel of Expert						Mean	Description
	T1	T2	T3	T4	T5	T6		
Design and Creative	10	8	10	8	8	10	9.0	Excellent
Questions	10	8	10	10	10	10	9.7	Excellent
Format and Purpose	10	10	10	10	10	10	10	Excellent
Directions	10	8	10	10	10	10	9.7	Excellent
Content and Difficulty	10	8	10	8	10	8	9.0	Excellent
						Mean	9.5	Excellent

Note. Poor: 2.00 – 3.6, Fair: 3.61 – 5.2, Neutral: 5.21 – 6.8, Good: 6.81 – 8.40, Excellent: 8.41 – 10.00

The table shows the evaluation of the in-service science teachers on the board game after the final implementation. The table shows the in-service teachers' rating towards the developed board game. The outcome demonstrated that the majority of the rubrics' categories received excellent ratings from the in-service teachers. Their rating has a grade mean of 9.48 which indicates excellent. Therefore, this suggests that the evaluators were highly satisfied with the developed board game in terms of Design and Creativity, Questions, Format and Purpose, Directions and Content and Difficulty.

3.3 Wilcoxon Signed Rank Test

Wilcoxon Signed Rank Test of the Pretest and Posttest scores during the Final Implementation

Table 4. Wilcoxon Signed Rank Test of the Pretest and Posttest

Variables	W-value	Mean Difference	Z-value	Standard Deviation (W)	P-value	Interpretation
Pretest	30.5	-7.65	-4.26	51.03	p < .00001	Significant
Posttest						

Table 4 shows the Wilcoxon signed rank test of the pre-test and post-test scores during the final implementation. a z-value of -4.26, consequently having a p-value of <.00001 which makes it highly significant. On the other hand, the w-value is 30.5, which corresponds to a normal distribution. The result indicates that the developed board game made an improvement in students conceptual understanding in photosynthesis.

Numerous research proves that a properly designed collaborative board game doesn't just gauge student interest but also deepens learning. It encourages communication, collaboration and improves learners' confidence in finding solutions to problems. Thus, putting a positive behavioral change to the students' learning (Treher, 2011).

4. Conclusion

Based on the findings of the study, the developed board game improved the conceptual understanding of photosynthesis in Grade 9. The improvement of their understanding was guaranteed by their pre-test and post-test scores. The scores of the students have improved after the integration of the board game along with the researcher's discussion. The developed board game contained question cards ranging from the classification of structures to explaining the functions and the food-making processes. The Grade 9 students were able to recall the different classifications and processes with the help of the board game. The board game had a point system depending on the questions chosen; thus, student understanding is a must to complete and win the board game.

Noda, Shirotsuki and Nakao (2019) also conducted a study on the effectiveness of the intervention of board games. The efficacy of the board game was divided into three categories: educational knowledge, cognitive functions and other conditions. The paper has revealed that the use of board games has a positive effect on various areas. In terms of their perception towards the board game, the evaluation's result had showed that pre-service teachers, Grade 9 students and in-service teachers have high regards with the development of the board game. Positive feedback was given to the board game in terms of design and creativity, entertainment and relation of its concept to science.

In addition, enhancing student learning became the most crucial factor in enhancing students' skills. Therefore, one of the best tools for increasing student interest and improving learning is game based learning. Adding interactive components to the mix of learning activities is increasingly necessary for successful and enjoyable student acquisition of deeper understanding. Scientists envisioned how hypermedia may be utilized as a cognitive tool for learning as early as the 1980s and 1990s. Brown (2002) emphasized that learning is acquired more as a result of the framework or the environment that it has taken place rather than as a result of the traditional teaching. Thus, there is a need for teachers to provide a complex level of interactivity that would stimulate the interest of the students.

5. Recommendations

Develop more game-based learning resources, rather than only board games, to improve game-based science education, particularly in biology. For this raises students' interest to concentrate and learn a concept. Researchers in the future are encouraged to come up with a digital version of the board game to support online learning, as the learners of the 21st century are referred to as digital natives. Additionally, the researcher suggests looking into other biological fields to expand on the concepts of the board game for future research.

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