Development of Board Game "City360" in Teaching Electricity for Grade 8 Learners

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ABSTRACT

The integration of board games into educational applications has shown significant promise in enhancing student engagement. The goal of this study is to amplify the knowledge of electricity, a difficult topic in Physics classes. The study used a developmental research framework with identifying the most difficult topic to teach and learn with teachers and learners respectively using a structured survey. The second phase was the evaluation of physics experts and science teachers' feedback into developing City360 board game, utilizing a mixed method of qualitative and quantitative support research design following the Successive Approximation Model. In the last stage, the intervention is implemented in Grade 8 classrooms in control group (without the exposure of the developed material) and experimental group (with exposure of the developed material) and the conceptual gain of the learners is evaluated. Analysis for qualitative insights, mean computation for rating scales, and normalized gain for quantitative assessment are examples of data analysis techniques used in this study. Moreover, ethically informed permission and participant's anonymity were given top priority. The main objective is to develop board games as a learning tool that improves learner's academic performance in the field of electricity. The developed "City360" received an "Excellent" rating from the 5 Physics experts and 6 Science teachers indicating that all areas of the work competently covered by the City360 board game. Hence, the current study suggested implementing the material and employing conceptual gains from a pre-and post-test before and after the utilization of the City360 to assess learners' understanding of electricity.

Keywords: Electricity, non-digital board game, Conceptual gain, Physics education, Game-based learning

INTRODUCTION

Filipino learners have consistently shown poor performance in science, as indicated by their low score in global assessment (Bernardo, 2023). Only 19% of Filipino students achieved scores in the low benchmark, which implied that the overwhelming majority of Filipino students "show limited understanding of scientific concepts and limited knowledge of foundational science facts" (Mullis et.al, 2020). This showed the current state of science education in the Philippines, particularly in the basic education level, lags behind other countries in the world despite the amplification of science instruction and learning throughout the world. Despite the Philippines' efforts to modernize its educational system with programs like K-12 and the Science and Technology Education for Economic Development (STEED) program, there is a noticeable gap when compared to other nations' achievements (De Guzman, 2018). In this sense, it was necessary to involve students in activities that promote interest and skills (Newhouse, 2016). Engaging students in science lessons can enhance their learning and reverse negative attitudes towards science, potentially increasing interest in pursuing science and related careers (Ateh, 2015). Recent studies (Deta et.al, 2023; Hermawati, 2022) emphasized that physics teachers face obstacles in teaching electricity, including inadequate facilities and difficulties in developing effective lesson plans and assessment methods. Hence, the integration of innovative tools may lead to clarifying the issues in science courses through the enhancement of students' learning

engagement (Loganathan et al., 2019; Vidakis et al., 2019). Numerous studies (Cardinot et.al, 2022; Bressler et.al, 2022; Teixeira et.al, 2022; Silveri, 2022; Neto et.al, 2023) supported that board games have been identified as effective tools to address the lack of engagement in science education. In a recent study, Low, J.Y. et.al (2024) used Catch the Flight board game to facilitate students' learning of resolution of forces and enhance their problem-solving skills. The researcher selected 41 upper secondary school physics students in the state of Perak, Malaysia. The results suggest that the game can offer students a positive player experience and, at the same time, enhance students' learning and motivation specifically to motion. Furthermore, Nguyen, T.T. et.al (2024) implied using board games in STEM education improves student engagement and understanding of STEM learning.

Although the use of game-based learning was quite popular, most of the games are in digital mode. Educational games like virtual board games developed with Adobe Flash have been shown to effectively teach concepts related to energy efficiency (Sperling et.al, 2022). Many areas of non-digital game-based are unexplored and there is still much to be explored on the utilization of non-digital game-based learning and its effect on the students' performance. To address these concerns, it was vital on the pedagogy of teachers to adapt on the constraint and pave the way to intervention that could harness student learning. The results of this research should provide insightful information on how board games might improve Physics education. This study aims to promote science education and improve conceptual knowledge among Philippine high school students.

The primary objective of this study is to develop and determine the effectiveness of the City360 board game in improving the understanding of electricity among grade 8 students in Philippine Integrated School Foundation, Inc. (PISFI) in the Philippines.

METHODS

Research Design

This study employed a Research and Developmental framework with a mixed method of qualitative and quantitative support in developing the board game. The researcher utilized this research design with aims to outline the process of developing and implementing board games. The qualitative data was gathered through the administration of a survey questionnaire after the exposure of learners to the board game. In the quantitative method, the researcher used specifically the quasi-experimental approach in which the experimental group and control group would be part of the study evaluating the effects of implementing the developed board game through achievement tests. With the aid of the modified instrument, the researchers would like to find out if a significant difference appears in the pretest and posttest scores of the two groups and the gain scores in the result of pretest and posttest between the two groups.

Research Subjects and Participants

The research subjects of the study were two sections of Grade 8 students of Philippine Integrated School Foundation, Inc. (PISFI). The inclusion criteria for the subjects are as follows: (a) currently enrolled in Grade 8; (b) secured the consent of their parents/guardian through consent form and (c) have no medical conditions that may affect their ability to learn. Furthermore, the board game packet was evaluated through the comments and suggestions from five (5) physics experts and six (6) science teachers which guaranteed the improvement of the board game packet before the implementation.

Data Gathering Procedure (Successive Approximation Model)

The data gathering procedure unraveled through a comprehensively structured process, commencing on the assessment analysis of SAM involving nine (9) science teachers/ thirty (30) grade 8 students for the most complex physics topic to teach and learn respectively advancing through design and development with the validation of the board game packet and culminating in the implementation and evaluation phase.

Preparation Phase

The information gathering marked the beginning of the study. It pertained to gathering all essential data for

edesigning and developing the board game in learning physics concepts. The researcher conducted an interview through online and face-to-face depending on the availability of the participating nine (9) science teachers to rank the physics topics in science 8 from difficult to the easiest topic to teach in the classroom and thirty (30) students from different schools were consulted to rank physics topics from difficult to easiest topic to learn. This was drawn to the aligned competency to be integrated from the Most Essential Learning Competencies of Curriculum Guide of the Department of Education. Thus, the researcher identified the game elements to be employed with the competency gathered from the interview as the content of the board game and achievement test.

Iterative Design, Development and Validation of City360 Board Game

The board game packet was meticulously crafted, addressing the identified competency and need during the preparation phase. The researcher identified various design principles in accordance with the development of the board game. In order to understand the teaching context, it was a necessary to (a) consider *time logistics* for learners to play games that can be easily implemented within the school class time (Cooke et.al, 2020); (b) *select the game mechanics* which referred to the players' action in the game such as how they move and interact with the game (Cooke et.al, 2020) and may add a new layer of difficulty for the educational game development depending on the game designer's previous experiences with games. It also covered (c) *challenges and constraints* which referred to rules or movements that enable or restrict play in different ways to maintain enjoyment and motivation to continue playing. However, there should be a balance in the number and level of challenges, based on the intended audience to prevent the game becoming boring or decreasing in flow (Cardinot et.al, 2022). The game was inspired by two commercial board games namely: Snake & Ladder and UNO Spin Wheel. It was anchored with the identified competency, challenges and constraints within the game. Various types of cards (e.g., trivia, command, and resource cards) introduced challenges and tasks, enhancing player engagement and learning outcomes (McSween, 2024). In the prototype part, designing the board game took place. The content of the packet was finalized.

After the board game packet's establishment, the polish board game packet was validated during the developmental phase. The final output was checked by various experts in the field (5 Physics experts and 6 science teachers) for the validity of the content including the board game design, color cards, mechanics, achievement test, and lesson plan. The overall design of the chosen game elements that were employed in the implementation was evaluated through rating scale and Comments and Suggestions Sheet. All comments and suggestions made were integrated into the board game packet. Throughout the phase, the researcher performed a total of three revisions to the developed board game.

Data Analysis

To get significant insights from the collected data, a variety of statistical tools were used in the data analysis process. Thematic analysis was utilized to analyze and evaluate the qualitative data gathered through the comments and suggestions part of the rating scale and the insights and feedback interview. The rating scale findings and intrinsic motivation questionnaire were examined by mean calculation, providing a numerical viewpoint in the board game packet. Normalized gain was used to determine the gain score of the participants after the implementation.

RESULTS AND DISCUSSIONS

Preparation Phase

The researcher conducted a survey to identify the most complex science topic for Grade 8 aligned with the K to 12 Curriculum. The respondents were both science teachers and students through online such as the use of messenger selecting the challenging topic to teach or learn in the competencies under the first quarter of Grade

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8 science curriculum. Out of the nine science teachers, three (3) teachers selected the competency code S8FE-Ih-30 (infer the relationship between current and voltage). Nine (9) out of the thirty learners-respondents selected the competency code S8FE-Ih-30 (infer the relationship between current and voltage) as the challenging topic to learn. The alignment of activities with MELCs was essential to guarantee that learners are provided with learning experiences that directly correspond to the targeted learning outcomes and provide teachers with a roadmap to design instructional strategies and assessments that help achieve learning goals (Holland, 2023).

Table 1. Aligning the Board Game Packet with the DepEd K-12 Identified Standards and Competencies

Content Standard The learners demonstrate understanding of..	Performance Standard The learners should be able to…	Most Essential Learning Competencies & K-12 CG Code The learners should be able to…	duration	Board Game Packet Objectives
Current-voltage-resistance relationship, electric power, electrical energy, and home circuitry	Discuss phenomena such as blue sky, rainbow, and red sunset using the concept of wavelength and frequency of visible light	Infer the relationship between current and voltage (S8FE-Ih-30)	Week 5-6	- Describe electric current, voltage and resistance and cite their differences. - Analyze the relationship of current to voltage and resistance in an electric current. - Apply the Ohm's law to real-life problems

Iterative Design, Development and Validation of the City360 board game

A game that is intended to be developed must be designed properly to achieve the objectives. Cognitive elements such as the color cards were employed to enhance the learner's cognitive level. Social elements, including action cards, action tiles are integrated to have an interaction among the players. Lastly, immersion elements like the time and game pieces are utilized to increase learner's involvement and interest in the developed board game. All of these game elements were implemented in the study. The research aimed to create a compelling experience that maximized learner's engagement.

Table 2. Game Elements Incorporated

Game Elements	**Design/Implementation strategies**
Color Cards	It is intended that the level of the difficulty of the question cards depend on the color of the card. The color cards consisted of three colors: red, blue and yellow. The colors represented different categories such as red for the easy questions, blue for the problem-solving questions and yellow for difficult questions. Number icon is attached with the question box which was used to match the card with the same number or the same color.
Action Cards	This element is designed to challenge the players based on the intended audience to prevent the game becoming boring or decreasing in flow.

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Action Tiles	This element is designed to constrain players to move to another tile.
Game Pieces	This element is designed to give players a chance to play in the City360 board game when a dice card is drawn.
Rules	It is set to ensure the smooth flow or experience of the board game.
Time logistics	Players are given a fixed time limit to draw cards, or to win the game.
Dice	This was designed to identify how many moves a player can move in playing City360.
Step Tiles	This element was designed to give players a challenge to the City360 board game. It is either the game piece will step up or step down.

The board game design consisted of one hundred tiles with house tiles which was used to identify if the player will draw cards - these draw cards were used to race who will win the game; situation icons which give consequence if the playing pieces will step up to higher tile or step down in lower tile such as establishment icon earning have a step up ladder or establishment in bankruptcy have a step down ladder; number icon which was the basis on what tile can a playing piece can move and special icons which represented some consequence or benefits in the duration of the game. Step up and step-down icons were represented with arrows.

For this study, the game set a fixed time limit for the players to match their color cards, use their action cards or shout "ACE" to win the game. This allowed the players to have ample time for the whole duration to control the longevity of the game. The components were the physical version of the board game which will be used to play when a dice card is presented, a rolling dice to identify how many movements the player can move in the board game, playing pieces which is used to interact with the game board, track the progress and execute the actions tiles. Challenges and constraints enable or restrict play in different ways to maintain enjoyment and motivation. In the developed board game, there are three elements identified to be used: (1) *action tiles* constrained players to move in another tile to reach the ACE tile; (2) *action cards* challenged the players by giving such as **Reverse Card** – Reverse direction of play, play changes direction to the right, and vice versa; and **Dice Card -** when a player present this card, s/he play the City360 board game. This was to maintain enjoyment and motivation to continue playing and balance in the number and level of challenges, based on the intended audience to prevent the game becoming boring or decreasing in flow. In terms of the color component, the study used three-colored color cards which were intended to the level of difficulty of the question cards depending on the color of the card. These elements were considered in an interactive approach to maintain the longevity, control and enjoyment in the whole duration of the game.

Table 3. Evaluation Rating Result

	Mean Rating	**Description**
Goals and Objectives		
The purpose of the game was fully explained.	4.27	Excellent
The goals and objectives of the game are clearly defined.	4.00	Good
The game covers key concepts of the topic.	4.22	Excellent
The game encourages students' interaction.	4.22	Excellent
The board game helps with recalling concepts or terms.	4.33	Excellent
Board Game Design		
The size of the board game is appropriate.	4.50	Excellent

The features of the board game are attractive.	4.00	Good
The materials used in the board game are durable.	4.44	Excellent
The board game is easy to use.	4.33	Excellent
Components and Organization		
The mechanics of the game are clear and easily understood.	4.22	Excellent
The terms used are appropriate to my level of understanding.	4.22	Excellent
The game pieces such as the characters, dice and questions are appropriate and well-aligned.	4.22	Excellent
The length of time to play is reasonable.	4.44	Excellent
Playability and Playfulness		
The game promotes healthy competition and cooperation.	4.44	Excellent
The rules and mechanics of the game provide players with equal conditions of fair play.	4.33	Excellent
The rules of the game make it fun to play.	4.22	Excellent
Usefulness		
The game is effective in introducing the topic.	4.11	Good
The game encourages the students to dig deeper into the subject matter.	4.11	Good
Playing the game is a productive use of time.	4.22	Excellent
Playing the game helps to understand the lesson.	4.56	Excellent
OVERALL MEAN	4.27	Excellent

Legend: Excellent 5.00-4.50; Good 4.49-3.50; Neutral 3.49-2.50; Fair 2.49-1.50; Poor 1.49-0.00

Table 3 displays the evaluation results of the eleven valuators for the City360 board game. All things considered, the data indicated that the City360 has excellent validity and acceptance (M=4.27). In addition, 14 out of 18 acceptability questionnaires received an excellent rating with the other four acceptability questionnaires received a good rating. The evaluators emphasized how innovative and interesting City360 is. They also made some recommendations about how to improve the City360 board game and serves as the basis for the refinement of the materials.

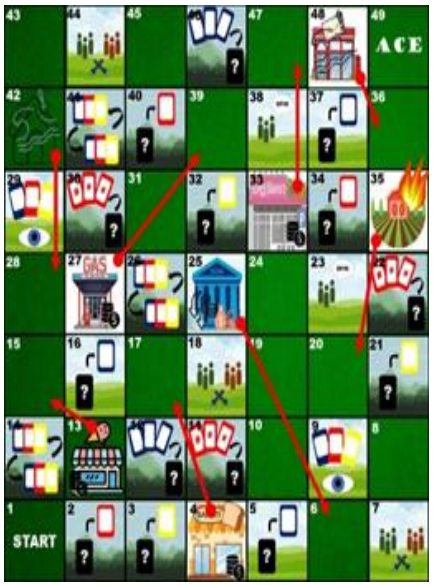

Figure 1

Figure 2

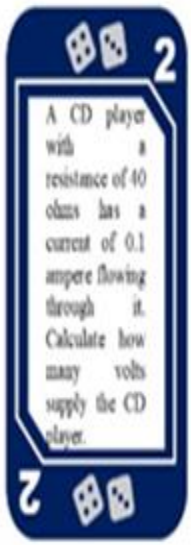

Figure 3

Figure 1 above shows the board game design of the packet that is used when a player draws a dice card. Figure 2 and Figure 3 are the color cards that are composed of dice cards and action tiles which are challenges. Each color card has a corresponding pair which is considered the question-answer pair card. When a player paired the same number as well as the same color, s/he had to shout FREEZE and read the pair card loudly. The first player to reach the last tile of the board game and shout "ACE" wins the game.

CONCLUSION AND RECOMMENDATION

The comprehensive need of strategic aid of grade 8 learners and science teachers that was carried out through survey as part of this study's topic selection has shown important obstacles and problems related to teaching and learning electricity. The knowledge acquired has greatly influenced the creation and evaluation of the City360 board game. This was validated by the evaluation rating of five (5) Physics experts and six (6) science teachers for which the assessing of City360 board game received an "Excellent" rating of acceptability. This study established a solid basis for assessing City360 board game's efficacy in enhancing grade 8 learners' academic performance of Electricity at Philippine Integrated School Foundation, Inc. by lacuna. These results implied the value of learning resources such as the City360 board game in filling the gaps in physics education, particularly when it comes to the topic of electricity. Thus, the present study recommends the use of "City360" to evaluate learners' comprehension of electricity using conceptual gains obtained from a pre- and post-test before and after implementation thereof.

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