Development of a STEM board game electriciladders for grade 8 students

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Abstract. This study aimed to develop a STEM board game Electriciladders for Grade 8 students under the K-12 Curriculum. The development was done through the different stages, namely: the selection stage, designing stage, assessment stage, and the enhancement stage. The developed rubric that was used to gather numerical data was validated by the experts. A sheet for comments and suggestions was also validated to gather the qualitative data. The board game was rated in terms of its creativity, rules and mechanics, accuracy of content, and knowledge as excellent. The assessment on the designed board game was the basis for its enhancement. Based on the ratings, the board game is an excellent tool to demonstrate the concepts of electricity. The developed board game can be a tool for an effective STEM learning.

1. The Problem and Its Scope

1.1. Introduction

Studying Physics is like an adventure. One will find it challenging to the point of being frustrated [1]. As a result, students whether from high school or college consider Physics as one of the difficult subjects. For this reason, teachers should teach Physics in a more interesting way that could awaken the interest of the students and will learn to love the subject. Tangible things which are directly accessible to their senses like a board game which integrates problem solving as players go along the way, help them develop their ability to understand abstract concepts, manipulate symbols, reason logically and to generalize.

In education, games are used as a teaching tool, motivational tool, and a facilitative tool. Hence, it is considered as a good instructional technology [2]. In addition, it is suggested that for a student to learn, one should make the learning experience a game-like enterprise, which could be in a form of a video game, board game, or a class competition [3].

1.2. Objective of the Study

This study aimed to develop a STEM board game as a tool in demonstrating the concepts of electricity among Grade 8 students and an instrument to promote STEM learning.

1.3. Scope and Limitation of the Study

The study focused on the development and enhancement of the board game Electriciladders. It was developed based on the topic Electricity of the First Quarter for Grade 8 students. It was tried-out by 30 pre-service teachers consisting of 20 fourth year BSED-Physics students and 10 first year BSED-Physics students of Mindanao State University-Iligan Institute of Technology (MSU-IIT) and in-service teachers comprising of the panel members including the thesis adviser. Since the game was based on the Snakes
and Ladders board game, extra questions were provided. However, the prepared extra questions may not be enough depending on the flow of the game.

1.4. Statement of the Problem
This study sought to answer the following questions:
1. How is the board game Electriciladders developed?
2. What are the ratings of the board game?
   a. In-service teachers
   b. Pre-service teachers
3. What are the comments and suggestions the board game?
   a. In-service teachers
   b. Pre-service teachers
4. What enhancements are done on the board game based on the comments and suggestions by the evaluators?

2. Related Literature and Studies
Research on students’ understanding of the simple electrical circuit concept has been conducted by some experts. From the results of that research, they found out that students have alternative conception of electric current, potential difference, and simple circuit [4]. As a solution to these misconceptions, teachers must be able to use varied methods, learning tools, and strategies to improve students’ understanding of Physics concepts. In addition, it is suggested that for a student to learn, one should make their learning experience a game-like enterprise which could be in a form of a video game, board game, or a class competition [3].

A study was conducted comparing lessons taught by traditional methods and lessons taught by using games. It was found out that students who were taught with games were more successful than those students taught by the traditional way [5]. Study also revealed that one of the most impactful uses of games is to motivate and reward students, particularly those who are low-performing. Aside from that, the use of games in lessons levitates students’ motivation as well as social and academic abilities such as memorizing, remembering, naming, matching, and classifying develop while playing a game [6]. One will also learn reasoning, relating cause and effect, focusing, directing oneself to an aim, realizing the problem that appear in the game and finding solutions to these problems [7].

A study mentioned if there is a board game that students can play on, then they will be able to assimilate new concepts more intuitively in addition to allowing the previously recorded information and organize it in a way to facilitate learning. He also stated in his study that board games enhance three styles of learning which are: Learning by listening, watching, and physically doing. Moreover, the use of board games in teaching Science will help students develop their content knowledge, desire to learn, social skills, and critical thinking [2].

An undergraduate thesis on the Modification of a Board Game Clash on Circuits in Teaching Direct Current Among Grade 8 Students, it was proven that board games are really useful and effective instructional tool in teaching. Based on the results they have gathered, the evaluators were delighted on how the board game was creatively made and was able to sustain the interest of the students to the lesson. Moreover, they concluded that board games could be an alternative way of teaching not just Physics related topics but as well as other subject areas [8].

3. Methodology

3.1. Subjects of the Study
The study was conducted at Mindanao State University- Iligan Institute of Technology (MSU-IIT). The developed board game was presented to Physics pre-service teachers of the Department of Science and Mathematics Education, and the in-service teachers who were considered as experts in assessing the board game. The first group of participants was composed of fourth year and first year Physics students.
of the Department of Science and Mathematics Education, College of Education, MSU-IIT. On the other hand, the second group was composed of the thesis adviser and the panel members.

3.2. Research Design
Quantitative method was involved because this study used a statistical tool to analyze numerical data from the assessment on the board game, wherein the respondents were given a rating sheet. Also, it involved qualitative method because the data were analyzed by identifying the context of the results from the ratings on the board game and the gathering of feedbacks from the respondents which served as a guide to the enhancement of the board game.

3.3. Instruments Used
The rubric was used to evaluate the developed board game. After the trial game, the evaluators were given a sheet for comments and suggestions so that they can write their thoughts on the board game. The enhanced version of the board game was based on these gathered data.

3.4. Data Gathering Procedure
3.4.1 Phase 1
Stage 1: K-12 Curriculum Guide and Educational Board Games
Before deciding on how the game board would look like, the topic and which grade level the board game is intended to, was the top priority. After the selection process, the next step was to search for educational board games which made the lay-outing of the game board a lot easier. Aside from that, those that were found were used as related literatures which supported the idea of the study.

Stage 2: Lay-out of the Board Game and Brochure
Right after the selection and searching process, it was decided to make a draft design of the board game and its brochure. Comments and suggestions of the panel members were put into consideration. These led to the redesigning of the board game and brochure which were used in the try-out.

Stage 3: Designing of the Board Game Electriciladders and its Brochure
With the comments and suggestions of the panel members, the board game was redesigned together with its brochure. The design was inspired by an already existing board game and the brochure was made to serve as a guide to the players to avoid confusion and not be lost in times when they forget how the board game works. In short, it contained the rules and mechanics of the game.

3.4.2 Phase 2
Stage 1: Assessment of the Board Game
This was the time when the respondents tried-out the board game and afterwards they were given rating sheet containing the rubric to evaluate the board game in terms of its creativity, rules and mechanics, accuracy of the content and the knowledge gained of the players in playing the board game.

Stage 2: Comments and Suggestions of the Respondents for the Enhancement of the Board Game
Right after the respondents have finished assessing the board game, they were given the comments and suggestions sheet where they can write their thoughts on the board game which was the basis for the enhancement of the board game.

Phase 3: Enhancement on the Board Game Electriciladders
The comments and suggestions of the respondents were taken into consideration by the researchers. The feedbacks that were gathered served as guide in enhancing their board game.

3.5. Statistical Analysis
The mean was used to determine the average rating of the respondents on the different aspects of the board game: creativity, mechanics and rules of the game, accuracy of content, and knowledge gained. To interpret the students’ level of satisfaction, the following descriptions were used: 1.00-1.74 (Poor); 1.75-2.49 (Good); 2.50-3.24 (Very Good); and 3.25-4.00 (Excellent).
4. Results and Discussions

4.1. Development of the Board Game Electriciladders

![Initial electriciladders.](image1)

![Final electriciladders.](image2)

The figures show that the first designed layout was drawn in a long bond paper consisting of 50 tiles with 7 ladders and 10 snakes and was named *Electrifying Snakes and Ladders*. But after the consultations to the panel members, the Electrifying Snakes and Ladders was thoroughly modified. The game board still consisted of 50 tiles with seven (7) ladders, but with 9 lightnings instead of 10 snakes, and twists like black tiles and VIP were added to spice up the game. Also, the name of the board game was changed from Electrifying Snakes and Ladders to Electriciladders. However, after being tried-out by the in-service and pre-service teachers, the initial Electriciladders was further enhanced. The in-service and pre-service teachers suggested changing the cartolinas to neon so that the game board would not look pale. Aside from that, they also suggested to find a sturdier board so that the game board would be more durable. Also, the arrangement of the lightning as well as the VIP was changed due to the pre-service teachers’ comment that the initial Electriciladders was crowded. The in-service teachers also pointed out to make the lightning appear brighter than the tiles so that players can easily see them. That is why it was decided to put glitters on them.
The figures show the changes made to the brochure. The table presented the draft guidelines which were written in a long bond paper containing seven (7) guidelines mixed with the power-ups. However, the same with the game board, there were also changes in the game’s guidelines. The initial Electriciladders brochure was created using Microsoft Publisher wherein the lay-out used in making the brochure was called blocks which was a ready-made brochure template of Microsoft Publisher. The revised brochure contained the Power-ups, rules and mechanics of the game and the consequences which a player must do in case he/she lands on a particular tile of the game board Electriciladders. However during the try-out, most of the pre-service teachers commented that the outside background of the Electriciladders brochure was pixilate. The researchers really intended it to be dimmed by lowering its brightness and contrast. With this comment, the background was turned into its original brightness and contrast.
The figures show the Electric ladders power-ups. The panel members suggested that it would be better if the power-ups would look friendly that instead of using skull, other icons may be used to represent this power-up. With this suggestion, the power-ups were changed from skull, imitation, and immunity to sword, Pokemon ball, and immunity. However during the try-out, the pre-service teachers suggested to change the icon of the second power-up to match with its function. That is why instead of using the pokemon ball, the toggle switch was used instead to represent the second power-up which is a power that lets a player exchange with his/her chosen victim.

Table 1. Rules and mechanics of the game.

| Draft Rules and Mechanics                                                                 | Initial Rules and Mechanics                                                                 | Final Rules and Mechanics                                                                 |
|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1. The game is to be played by group. Each group consists of only three (3) members.       | 1. The game must be played by at least 2 players. When the number of players exceeds 2, they can form groups and play by team. | GOAL: EACH PLAYER MUST COLLECT FIVE (5) DIFFERENT COLORED ENVELOPES                       |
| 2. For each group, they are given three (3) special powers.                                | 2. Before the start of the game, each player or team will be given a score sheet, newsprints, and power-up icons. Score Sheet– will be used to tally the points garnered by each player/team. Newsprints– will be used as a scratch paper for word problem questions. Power-up Icons– will be used as an advantage in the game. | 1. The game must be played by at least 2 players. When the number of players exceeds 2, they can form groups and play by team. |
| 1st power SKULL- it is a power which unable a team to take their turn.                      | 3. Each player must select a POKEMON CHARACTER of his/her choice.                          | 2. Before the start of the game, each player or team will be given a score sheet, newsprints, and power-up icons.  |
| 2nd power IMITATION- it is a power which enables a team to copy the move of the other team. | 4. Next, each player/team will take turns in throwing the dice in the board game to determine their order. The player with the highest number of dots will be PLAYER 1, while the second highest will be PLAYER 2, and so on. | • Score Sheet– will be used to tally the points garnered by each player/team.         |
| 3rd power IMMUNITY- it is a power that enables a team to have immunity to the snakes.      | 5. To start the game, PLAYER 1 must pick a question from the mystery box under the label “PER ROLL OF DICE QUESTION” before he/she could move according to the number of dots appeared upon throwing the dice. Followed by PLAYER 2 and so on. | • Newsprints– will be used as a scratch paper for word problem questions.            |

Note: The power Skull and Imitation can only be used by a team when it’s their turn. The Immunity can be used before they read the question.

3. The group will roll a dice in order for them to know who will play first. So the player who gets the highest number of dots will play first followed by those who got higher number, and so on and so forth.

4. Whenever a player encounters a ladder, the player has the chance to climb on the ladder if and only if they are able to answer the given questions.

5. To start the game, PLAYER 1 must pick a question from the mystery box under the label “PER ROLL OF DICE QUESTION” before he/she could move according to the number of dots appeared upon throwing the dice. Followed by PLAYER 2 and so on. If the player answer the question correctly, he/she can move and gain a score, but
5. If ever the player encounters a snake, they can remain on the same tile if they are able to answer the given question. But if the player failed to do so, then they are obliged to move down.

6. The first group who arrives at the finish line wins the game. The second group who arrives again at the finish line will rank 2nd, third to arrive will be 3rd, and so on and so forth.

7. If the player gets a number of dots that exceeds to the finish tile, then they will have to move backwards according to the number that exceeds.

· If the player failed to answer the question correctly, he/she cannot move and will not gain the points for that question.

· If the player answer the question correctly, he/she can move and gain a score, but if the player failed to answer the question correctly, he/she cannot move and will not gain the points for that question.

**POINT SYSTEM:**
Multiple Choice Questions – 2 points
Word Problem Questions – 5 points
Scientist Questions – 2 points

6. In the game, you will encounter the following:

- **YOU’LL HAVE TO ANSWER A QUESTION ABOUT A PARTICULAR SCIENTIST**

- **BLACK TILE MEANS “MYSTERY CHALLENGE”**

- **YOU’LL GO DOWN**

**NOTE:** YOU WILL NOT GO DOWN IF YOU CAN ANSWER A WORD PROBLEM QUESTION

- **YOU’LL GO UP**

7. Whenever a player/team passes by the last tile in a row, he/she will gain a set of circuit components which they will use to construct both series and parallel circuits. And in order to do this, the player/team must collect a total of 5 different colored small paper containers.

- **YOU’LL GO DOWN**

**NOTE:** IF THE PLAYER REFUSE TO DO THE CHALLENGE, HE/SHE WILL BE DEDUCTED WITH 5 POINTS

- **YOU’LL GO UP**
Whenever a player/team passes by the last tile in a row, he/she will gain a set of circuit components which they will use to construct both series and parallel circuits. And in order to do this, the player/team must reach the 50th tile to completely collect all the circuit components.

Compared to the initial version of guidelines, the rules and mechanics in the Electriciladders brochure were more organized and easy to understand. In the initial version, the power-ups were mixed with the rules and mechanics, but in the final brochure, the rules and mechanics of the game were separated from the power-ups. However during the try-out, one of the in-service teachers suggested that the goal of the game may be placed on top before the step-by-step explanation on how the game works so that the players could already set the end in their mind. Aside from that, one of the pre-service teachers suggested to give time allotment for every question. That is why in the final rules and mechanics, the multiple choice as well as the scientist questions can be answered within 15 seconds while word problems have to be answered within 30 seconds. The questions are shown below.

**Figure 7.** Multiple choice questions.

**Figure 8.** Scientist questions.

**Figure 9.** Problem-solving questions.

### 4.1.1. Other Elements of the Game

![Pokemon characters](image-url)
Pokemon was chosen as the game’s theme because of Pikachu which has the electrifying ability, since the board game was based on the topic Electricity. The purchased Pokemon figures were bought at 25 pesos per box wherein each box contains 4 figures, each of which are distinct from one another. The figures below show the circuit components of the game.

![Figure 11. Bulb components.](image1)
![Figure 12. Wire components.](image2)
![Figure 13. Battery components.](image3)

4.2. Ratings on the Electriciladders by the Evaluators

| Category                        | Mean Rating | Description |
|---------------------------------|-------------|-------------|
| Creativity                      | 4.0         | Excellent   |
| Mechanics and rules of the game | 4.0         | Excellent   |
| Accuracy of content             | 4.0         | Excellent   |
| Knowledge gained                | 4.0         | Excellent   |
| Total                           | 4.0         | Excellent   |

Legend: 1.00-1.74 (Poor); 1.75-2.49 (Good); 2.50-3.24 (Very Good); 3.25-4.00 (Excellent)

Table 2 shows the ratings of the in-service teachers to the board game. Based on the table, the in-service teachers rated all of the categories as excellent. This only shows that the in-service teachers were pleased on how the board game was creatively done, which implies that the board game can be another avenue...
for the students to not just simply learn Physics concepts but to enjoy while learning them. Moreover, based on the results presented in the table above, the overall impact of the board game starting from its content down to its rules and instructions is excellent.

Table 3. Mean rating of the pre-service teachers.

| Category                     | Mean Rating | Description |
|------------------------------|-------------|-------------|
| Creativity                   | 3.9         | Excellent   |
| Mechanics and rules of the game | 3.87      | Excellent   |
| Accuracy of content          | 3.83        | Excellent   |
| Knowledge gained              | 3.73        | Excellent   |
| Total                        | 3.83        | Excellent   |

Legend: 1.00-1.74 (Poor); 1.75-2.49 (Good); 2.50-3.24 (Very Good); 3.25-4.00 (Excellent)

Table 3 shows the ratings of the pre-service teachers to the board game. The pre-service teachers rated the board game as excellent in terms of creativity, rules and mechanics, accuracy of content, and knowledge gained. Furthermore, they found out that the board game is appropriate for the Grade 8 students in terms of the game board designs, questions, and instructions. This implies that the board game can be used to help students understand Electricity even better as well as in monitoring the students’ understand of the subject matter. Most importantly, through this board game students will be motivated to learn not just Electricity but other Physics related concepts.

5. Conclusion

Based on the results and findings of the study, the developed board game was an excellent tool in demonstrating the concepts of electricity among Grade 8 students. The board game was enjoyable, entertaining, interactive, and easy to learn. It can help students to improve their memory, develop problem-solving skills, and handle decision making. Thus, the board game Electriciladders can be a tool for promoting an effective STEM learning.

6. References

[1] Young H and Freedman R 2000 University Physics, 10th edition. California: Addison Wesley Publishing Company Inc. pp 669-671
[2] Alfaifi K M 2013 Using Board Games to Teach Physics EWU Masters Thesis Collection Retrieved January 13, 2019 from http://dc.ewu.edu/theses/169
[3] Gee J 2005 Why Video Games Are Good for Your Soul: Pleasure and Learning Australia: Common Grounds Publishing
[4] Setyani N, Suparmi S and Handhika J 2017 Students’ Conception and Perception of Simple Electrical Circuit Retrieved August 13, 2018 from https://www.researchgate.net/publication/321311251_Students_conception_and_perception_of_simple_circuit
[5] Romine X 2004 Using Games in the Classroom to Enhance Motivation, Participation, and Retention: A Pretest and Post-test Evaluation Culminating Experience Action Research Projects pp 283-295
[6] Korbey H 2014 Surprising Insights How Teachers Use Games in the Classroom Retrieved August 13, 2018 from https://www.kqed.org/mindshift/36160/Surprising-Insights-How-Teachers-Use-Games-In-The-Classroom
[7] Dagbasi G 2007 Use of Game Techniques and Arabic Language Teaching High License Thesis Ankara: Gazi University
[8] Lacida J and Rollan J 2018 Modification on the Board Game Clash on Circuits in Teaching Direct Current Among Grade 8 Students S.Y 2017-2018 (Unpublished Thesis) College of Education, Mindanao State University- Iligan Institute of Technology