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The Use of Educational Board Game as a Supplemental Tool in Learning Periodic Table of Elements Among Senior High School Students

Lalaine N. Alejandria¹, Jill Mie S. Bajenting¹, Marie Anne Lovella D. Pacatan¹, Tomas Jr A. Diquito^{1*}

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ABSTRACT

This study aims to assess the effectiveness of the created educational board game as a supplemental tool in learning the core concepts of the periodic table of elements. A quasi-experimental approach was utilized in addressing the objectives of the study wherein a total of thirty-two (32) students from the STEM strand participated in the study (sixteen (16) experimental group, sixteen (16) control group). An interview was also conducted after the post-test to determine the students' experiences while playing the board game. The result of the study revealed that there is no significant difference in the pre-test mean score of the control ($M=41.750$, $SD=13.959$) and experimental group ($M=48.938$, $SD=10.221$); ($t(30)=1.66$, $p>.05$). However, the post-test mean scores show a significant difference in the control ($M=26.063$, $SD=19.223$) and experimental group ($M=57.268$, $SD=13.169$); ($t(30)=1.42$, $p<.05$). This means that the created educational board game is an effective supplemental tool in learning the concepts of the periodic table of elements. In addition, the interview revealed that participants enjoyed the game and recommended that the game be utilized in learning the periodic table of elements. Based on the findings, the researchers recommended that the created educational board game be utilized as a supplement in teaching the periodic table of elements in chemistry subject.

INTRODUCTION

Chemistry is seen as one of the most important fields of science wherein learning in this field requires higher-order thinking skills, knowledge and laboratory skills. One of the basic concepts that learners must acquire first in chemistry is the periodic table of elements. However, the students face a dilemma in learning these basic concepts, primarily the facts and components of the periodic table of elements (Alias & Ibrahim, 2019). To bridge the gaps of knowledge acquisition of least learned concepts, game-based learning is being introduced (Zirawaga, Olusanya & Maduko 2017). In chemistry, competencies such as memorizing and arranging the elements are seen as the most difficult to learn (Hadiprayitno, Muhlis & Kusmiyati, 2019). In the scientific study of chemistry, the periodic table is increasingly widely used, providing a highly useful framework for classifying, arranging, and comparing all the many variations of chemical activity. Games are important in science to improve learners' educational experience while teaching other skills such as rule ability to follow, ability to adapt, creative thinking, communication, team building, and fair play in which students learn and acquire concepts through repetition or cramming.

Theory of constructivism that was developed by Piaget (1962), noted that people acquire knowledge through combining their thoughts and experiences. Piaget argues that the individual is at the center of the process of knowledge construction and acquisition thus, the conception of constructivism serves as the inspiration for radical constructivism. Piaget further added that information could not be passed down, memorized, recovered and used from generation to generation. Moreover, the three basic categories of games defined

by Piaget are sensorimotor play, role-playing and games with rules. Among the different types of plays, it was said that games with rules are defined by competitiveness and sustained control. As a result, Piaget considered games with rules an effective technique for increasing knowledge because learners must learn to regulate themselves in the face of different perspectives on how games should be played. Students can benefit from this game in a number of ways, including enjoyment, fulfillment, and learning a new method or approach to acquiring knowledge and abilities. According to Piaget, children play in ways that correspond to their stage of cognitive development. Children work through play to improve their cognitive abilities and acquire new knowledge. Moreover, they also study and practice social skills, enhance their communication abilities, they design, investigate, and acquire strategies for quick memory recall through their experimenting with educational materials.

The use of games was motivated by the assumption that it enhances cognitive and higher-order thinking skills. It is also often used to increase the learning process. Sandford, Ulicsak, Facer & Rudd (2006), as reported by Alabbasi (2018), noted that, teachers believe that games promote student involvement, interaction, and engagement in the classroom. Francisco-Mariscal, Olivia-Martinez, Blanco-Lopez & Espaa-Ramos (2016) also mentioned that game-based learning is the most effective approach to be used in teaching. Thus, using this as an approach or strategy in a classroom setting provides opportunities for educators to enhance their teaching pedagogy. The term "scaffolding" was created by Wood, Bruner, and Ross in 1976 to describe how an adult or expert teaches a student who cannot solve a problem or complete a task (Plass,

¹ Department of Teacher Education, University of Mindanao, Digos, Philippines

* Corresponding author's e-mail: tomasdiquito@umindanao.edu.ph

Homer, & Kinzer 2020). Appropriate feedback and support are given in response to each student's feelings as they play the game, especially when one or more of them is having difficulty. This dynamic input is offered to support gameplay learning to learn to listen to the suggestions of the players and to offer some advice to make the players more excited about playing the game and learning.

To realize the idea of Piaget on his theory of constructivism and the theory of scaffolding by Brunner, a promising approach was created by educators worldwide, the game-based learning approach. Creating board games is an effective way to get students to consider playing board games. Kessner & Siyahhan (2021) found that designing board games in a meaningful context motivated the students in both design creating and system thinking in response to the recent increase in interest in designing tools for learning about educational board games (Ramesh & Sadashiv, 2019). Moreover, the use of board games in chemistry, especially in different chemistry concepts, is promising. William (2020) explained that games in chemistry help students practice applying and familiarizing the concepts in chemistry. Students enjoyed playing the game, found it easy to play, and found it a useful learning experience. Huang (2020) also noted that student engagement, flow experience and learning outcomes all are highly enhanced by board games. Moreover, the emphasis on constructivist learning is associated with high acceptance among students (Languita *et al.*, 2023). Thus, innovation in educational board games is crucial to the future of teaching and learning. Board games are one such modern educational tool that can be used to address concerns regarding chemistry quality education (Ramesh & Sadashiv, 2019)

In the Philippines, Galoyo (2021) reported that games are an integral part of a student's everyday routine. These games serve as a variety of functions for students, including enjoyment, satisfaction, and learning a new approach or technique to learn new things, master new skills and even surpass competitors, as most players assert. Van Eck (2006) as cited by Galoyo (2021), found out that both non-digital and digital games have continuously enhanced learning and reduced instructional time in their study on Digital Game-Based Learning. In these games, virtual and physical materials are used to satisfy specific educational demands such as data manipulation. Physical interactions include physical objects, symbolic representation and physical encounters. Using educational board games in the classroom not only allows the students to review information, but it also creates an environment that encourages them to participate and plan, making them more active and cooperative. In addition, it highlights the usefulness of the periodic table of games and its effects on learners' academic progress (Ong & Linaugo, 2019)

In this study, the researchers determined the usefulness of an educational board game as a supplement to learning the periodic table of elements through this study. This research would be useful to students who are enrolled

in Grade 12 Science, Technology, Engineering, and Mathematics (STEM) having difficulty in taking chemistry courses, particularly general chemistry and inorganic chemistry, which have periodic table of elements as core concepts. Also, as a supplement to teaching the periodic table of elements, this would benefit teachers teaching basic concepts of the periodic table of elements. Finally, the UM as an institution is providing the students a new educational tool for learning.

Research Objectives

This study aimed to investigate the effectiveness of the educational board game as a supplemental tool in learning the periodic table in Senior High School students in UM Digos College in Science, Technology, Engineering, and Mathematics (STEM) strand. Moreover, it sought to answer the following objectives:

1. to determine the performance of students according to the classification of groups in pre-test and post-test;
2. to determine if there is a significant difference in the pre-test and post-test scores of the respondents; and
3. to find out students' experiences while playing the educational board game.

METHODS

Respondents

The respondents of this study were Grade 12 Senior High School Students of UM Digos College that were officially enrolled in Science, Technology, Engineering and Mathematics (STEM) strand in the School Year 2021 - 2022. In addition, only students who took chemistry subjects in this School Year were included as the study's respondents. A total of 16 students participated in the experimental group, which utilized the newly designed board game material, and another 16 students participated in the control group, which used non-game-based learning resources (guide sheets). This was determined through the use of the random sampling technique, where all odd scores were assigned to the experimental group and all even scores to the control group. All the respondents in both experimental and control groups willingly volunteered themselves to take part of this study.

Instrument

In this study, the researchers generate 140 MCQ about the periodic table of elements in relation to the principle of the game. There were 70 questions for the Pre-test and 70 questions for the Post-test. The researchers created these questionnaires and validated by two (2) experts to determine the validity of the developed questions. Moreover, the researchers also created and developed a chemistry-board game for the implementation and its manual on how to play the game and guide sheets containing description of elements, common characteristics and its properties utilized in this study.

Design and Procedure

This study adapted the Quasi-Experimental Research

Design for quantitative and Descriptive Research Design for qualitative. The researchers undertook a quasi-experimental study to evaluate the effectiveness of the educational board game as a supplemental tool in learning the periodic table of elements among senior high school students using the Pre-test and Post-test approach. This method involves a process of testing of the variables, which includes comparing the effects of one variable to the other variable. This method, according to Malhotra, Agarwal & Peterson (1996) as cited by Rahi, (2017) was utilized when researchers investigate cause and effect relationships between variables. Additionally, the researchers performed a descriptive qualitative research study to investigate into, observe, and measure one or more variables. Erickson (2017) claims that it addresses the common issues with questionnaires, including respondent cooperation, instrument design, and administration technique. The focus is on broad trends in observational research (or observation and communication), on continuing interactions with respondents, and on engagement. Furthermore, qualitative content analysis was used to organize and interpret meaning from the information gathered by the researchers in order to come to reasonable conclusions. As stated by Lindgren, Lundman, & Graneheim (2020), qualitative content analysis is a structured method for analyzing qualitative data. It provides the possibility to examine observable and descriptive information together, forming categories.

Moreover, the following are the steps and procedures before, during, and after the study: First, the researchers created an educational-board game highlighting the concept of the periodic table of elements (*see Appendix A for the complete mechanics*). In this step, the researchers also created the rules and mechanics of the game. After crafting the educational board game, a game demonstration was conducted to ensure that the technicality of the game, including its rules and mechanics, is congruent with the objectives of the study's objectives. After the demonstration, the researchers updated the game's mechanics based on the demonstration's findings. Similarly, the researchers crafted a set of questions (pretest and posttest) that were implemented before and after the implementation of the game. Second, after the preparation phase, the researchers proceed with the preliminaries prior to conducting the study. The following preparations were observed properly: (1) The researchers undergo validity checking to the created game and a set of questionnaires. After the process, the researchers updated any changes to the game or mechanics as well as the set of questions. (2) Securing letters and approval from the Research and Publication Office of the University of Mindanao - Digos, Dean of College, and School principal. Once approved, another letter was sent to the study's respondents indicating the agreement that they had participated in the study.

Fourth, after the rigorous process, the researchers conducted the study. The following procedures were strictly followed: (1) conducting pretest to the target respondents of the study, based on the results of

the pretest, students were grouped into two groups: the experimental group and the control group. The method of grouping students is based on the odd and even distribution. All odd scores were designated as the experimental group, while even scores were designated as the control group. (2) After the groupings, the researchers began implementing the game for the experimental group. The researchers introduced the students to the mechanics of the game. After this, the game was implemented for one month (twice a week). Because the game is a physical board game and students cannot attend the school, the researchers used online conferencing tools such as Google Meet or Zoom to facilitate the game. (3) After one month, the researchers administered a posttest to two groups to determine the effectivity of the game in the experimental group. In addition, the researchers surveyed the students' effectiveness and experiences in the created educational board game. Fifth, after implementing the educational board game, a posttest was carried away from the experimental and control groups. An interview was also carried out to the selected participants in the experimental group. After obtaining the needed data, an analysis was then carried out. The researchers would keep all the important documents for three years in a secure and safe place for the confidentiality of the respondents' background and the right to keep it hidden.

Data Analysis

For the quantitative phase the researchers used Mean and independent sample t-test in data analysis. The mean score was used to compute the scores of the experimental and control groups, as well as the independent sample t-test to compare the mean scores of both groups and determine if there would be any difference in the respondents' pre-test and post-test scores on applying the created educational board game (Malik, Qin, & Ahmed 2020). While, the Independent Sample t-Test analyzes the means of two separate independent groups to see if there is statistical support that the population mean values are statistically substantially different (Kent State University Libraries. 2017). In the qualitative phase, Becker Quasi-statistics is being utilized to validate the verbal statements because the questionnaire items are created from qualitative data. It is critical in qualitative research to make the quasi-statistical basis of their conclusions explicit (Maxwell 2010 as cited by Moltudal, Krumsvik, Jones, Eikeland, & Johnson 2019).

RESULTS AND DISCUSSION

This part of the study presents the findings of the conducted study, including data interpretation and analysis, regarding the effectiveness of educational board game as a supplemental tool for learning the periodic table of elements among senior high school students.

Significant Difference in The Pre-Test and Post-Test Scores of The Respondents.

Table 1 shows the result of the independent sample

t-test in the pre-test and the post-test scores of the experimental and control group. Data shows that there is no significant difference in the pre-test mean score of the control group ($\bar{x} = 41.750$, $SD = 13.959$) and experimental group ($\bar{x} = 48.938$, $SD = 10.221$); ($t(30) = 1.66$, $p > .05$) since both groups were on the same level of intelligence before the intervention. However, the post-test mean scores showed a significant difference in the control group ($\bar{x} = 26.063$, $SD = 19.223$) and experimental group ($\bar{x} = 57.268$, $SD = 13.169$); ($t(30) = 1.42$, $p < .05$) since the scores of both group had a different level of intelligence after the intervention. In addition, the SD results between groups showed a large gap since the post-

test scores in the experimental group were closer to the mean scores compared to the SD result of the control group. In conclusion, the null hypothesis was rejected, and thus, found that the designed educational board game is effective in learning the concepts of the periodic table. The results mentioned above that were evaluated had a highly favorable effect on the implemented educational board game in learning the periodic table of elements. Franco-Mariscal, Oliva-Martínez, Blanco-López & Espana-Ramos, (2016) stated that students can learn chemistry subjects well by using educational board games rather than traditional teaching, making the topics of chemistry subjects a lot more simplified. Sung, Hwang,

Table 1: Result of Independent sample t-test on learning periodic table using the educational board game

	Group	Mean	SD	t	p
Pre-Test	Experimental Group	48.938	10.221	1.66	0.107
	Control Group	41.750	13.959		
Post-Test	Experimental Group	57.268	13.169	1.42	<0.01**
	Control Group	26.063	19.223		

** $p < .05$ (The independent sample t-test is significant if the p-value is less than 0.05)

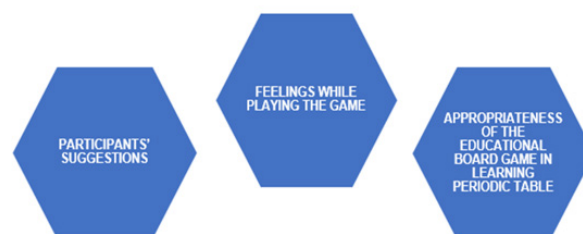
Lin, & Hong (2017) stated that numerous research has demonstrated that an experiential game-based learning approach may increase students' motivation to learn through experience by appropriately integrating learning content into game scenarios. Additionally, the experiential game-based approach is a teaching strategy that has a lot of promise for inspiring students and increasing their desire to engage in ongoing and consistent learning. Moreover, it will be a strategy to improve students' learning outcomes in terms of their willingness to study, deep learning strategy, and technological acceptability. Therefore, it has been determined that an experienced digital game-based learning strategy can assist students in understanding the notion and meaning of learning, which is crucial for them to become lifelong learners with favorable learning attitudes.

Additionally, students participate more in class when educational games are used, which enhances their interest and participation in the lectures. Furthermore, educational games can be seen as powerful modern instruments that, when used correctly, significantly help the teaching and learning process. It was also shown that the experimental group performed significantly better than the control group in terms of motivation for academic performance. The results also showed that the educational board game affected science students' motivation for academic achievement. With this in mind, it is possible to see the games as a useful instrument for resolving the conceptual difficulties associated with the question unit. As Nizam & Law (2018) claim, according to Piaget's theory, games are a child's primary means of world exploration, and that the games they play is a sign of how well they are developing cognitively. Games can therefore be divided into three stages: functional play for building sensorimotor abilities (from birth until age two);

symbolic and pretend play for learning experiences to develop useful concepts (between ages two and seven); and games with rules for improving social skills (7 years and older). In addition to this, Ribeiro & Maria do Céu (2019) also claim that the game is a great teaching and learning approach since it enables students to build their social and communication abilities, which sets them up for learning. For this, the results proved that games that are included in learning methods also encourage deep and long-lasting learning. Given their powerful ability to motivate and engage players, games are being used more often for information processing. Therefore, in games, it can develop recognition and memory characteristics that will help the students or learners easily learn the periodic table of elements with fun.

Experiences of the Students in Using EBG

The interview revealed that all the chosen participants are willing to use the educational board game as a supplemental tool for learning a periodic table of elements. Participants indicated that the use of educational board game as a supplemental tool in learning periodic table of elements is.



Participants' Suggestions

Based on the interview, researchers obtained suggestions from participants, and they have various suggestions for using an educational board game as an additional

tool for senior high school students to understand the periodic table of elements. The players discussed what they thought should be changed or taken out of the board game that had been introduced. Three participants made the suggestion that the researcher should use a 2 dice instead of a 1 so that the game would end quicker

than usual. Furthermore, three participants suggested including questions like “what is the purpose of that element,” while two participants had no suggestions or recommendations at all because they were happy with the results as they were.

No.	Participant’s Response	Number of Response/s
1	“I recommend using two dice in the game to make the game faster” (Participants 3, 6, 7)	3
2	“I recommend adding application, like what is the use of the element” (Participants 1, 4, 5)	3
3	“No suggestions and recommendations” (Participants 2, 8)	2

Feelings while Playing the Game

When the students were asked what they felt while playing the implemented educational board game, seven of them said that it made them feel both excited, enjoy and nervous as well, since it was their first experience with an

educational board game. One respondent said that they were aware that this game has been used in other board games and still enjoy it since it is applied to the periodic table of elements with a twist.

Researchers are now examining how scaffolding affects

No.	Participant’s Response	Number of Response/s
1	“I am nervous at first because I am aiming to become the top player but later, I feel enjoyment while playing the game” (Participants 1, 7, 8)	3
2	“The game is fun and exciting” (Participant 2, 3)	2
3	“Playing the board game is exciting” (Participant 4)	1
4	“The game was fun, and it is new to me since I haven’t tried many educational games before” (Participant 5)	1
5	“I feel joyful for myself while playing the game” (Participant 6)	1

learning outcomes and student experiences when utilized to enhance Game-Based Learning (GBL) among students. Games with question prompts can foster curiosity, interest, learning attitudes, and flow experiences, according to research by Hwang, Wu, and Chen (2012), which is reinforced by Chen & Law (2016). In addition, gamification, which is used to refer to the use of games or other interactive activities that combine fun and learning, is one method of engaging or stimulating the student, according to the study by Pieroni, Vuano, and Ciolino (2000) as cited by Montejo Bernardo & Fernández González (2021). There are countless instances in the research where activities like card games and board games like Taboo or bingo, crossword puzzles, building blocks, team exercises, or even sporting events can encourage kids to learn about the periodic table of elements. In addition, their study also made mention of the possibility of using the educational board game Chemical Battleship to engage young students in chemistry in a fun way. This article describes how to use the game with learners at various academic levels, from middle school kids to college students.

As digital games and other associated digital media have grown increasingly advanced and intentionally educational, it has been possible to identify ways to use the scaffolding that naturally occurs during play in the digital world to improve learning. The term “scaffolding” was created by Wood, Bruner, and Ross in 1976 to

describe how an adult or expert teaches a student who is less able to solve a problem or complete a task (Plass, Homer, & Kinzer 2020). Appropriate feedback and support are given in response to each student’s feelings as they play the game, especially when one or more of them are having difficulty. This dynamic input is offered to support game play learning and to learn to listen to the suggestions of the players and to offer some advice to make the players more excited about playing the game and learning.

Appropriateness of the Educational Board Game in Learning Periodic Table

When their thoughts and insights were asked about if the educational board game is helping them to learn new things or if the implemented educational board game adds new knowledge about the periodic table of elements, all of the students stated it would be helpful. All the answers are listed below;

Educational games are widely viewed by students as an engaging method to enhance learning of a specific subject or topic. According to Poole, Clarke-Midura, Sun, and Lam (2019), peer scaffolding may also be provided through board games to promote peer engagement and academic performance. The fact that students felt more engaged and gave a better evaluation of what they had learned, reaching a deeper and longer-lasting understanding, increasing their experience of

No.	Participant's Response	Number of Response/s
1	"The game should be utilized in the chemistry subject... especially to those learners who have difficulty in learning concepts of the periodic table of elements" (Participants 1, 3, 7)	3
2	"The game helps me to identify the atomic number, electrons, protons of the elements and where they belong" (Participants 2, 8)	2
3	"The game helps me know the unknown elements at my end" (Participant 5)	1
4	"The game helps me identify elements and familiarize the different characteristics of elements" (Participant 4)	1
5	"The game helps me broaden my knowledge about periodic table of elements (Participant 6)	1

flow, and improving their learning achievement, shows that students have more favorable opinions of the games. Students also prefer to learn in a playful, motivating, and exciting way. The opinions show that games also stimulated their participation in classroom activities (Chen, Hou, 2020). Additionally, the periodic table is an important topic for the teaching and learning of science at all educational levels since it provides information on the fundamental physical and chemical properties of the different elements that make up matter. For this reason, playing this game makes it possible to teach chemistry at particular educational levels in an entertaining way. As indicated by the improvement in their grades, students not only improved their subjective assessment of their knowledge, but also what they actually knew about the periodic table (Montejo Bernardo, Alfonso Fernández González 2021).

CONCLUSION

This study aimed to determine if the created supplemental tool in learning periodic table is effective. The study revealed that the educational board game would improve student's academic performance in chemistry, particularly in terms of learning and familiarizing themselves with the periodic table of elements. After the intervention, researchers found a statistically significant change between the pre-test and post-test scores of the senior high school students because the student's post-test scores improved over the pre-test scores. In corresponding with the theory of Piaget, it states that children explore the world primarily through games, and the games they play show how well their cognitive development is progressing. Therefore, game-based learning, specifically using an educational board game has a greater influence on their classroom participation and enhances their cognitive development. Students provided positive feedback when they were interviewed using the Focus Group Discussion (FGD) approach via Google Meet. While playing the educational board game it has a variety of emotions that will arise during the game.

The students experience excitement, happiness, and nervousness while playing it. In addition, the educational board game was intense due to the twist that the researchers created that will make the player more eager to win the game with lessons. In connection to Bruner's theory about scaffolding, it describes how the facilitator

guides a student who is less able to solve a problem or complete a certain task and giving support to make the students learn to open up their minds to suggestions, advice, or hints, makes the students feel more excited and have fun more in playing the educational board game. The researchers observed that with this game, students socialize, improve their communication skills, and have fun while learning all the way through. As the implementation of the educational board game as a supplement for studying periodic table of elements, it is quite favourable that this method of learning will replace traditional teaching methods because it is extremely successful even though it is not being widely used in the past. Moreover, this has been a helpful and innovative method to learn things while having fun, especially considering the current pandemic. Therefore, educational board games help students to use this as a supplemental tool for easy ways to learn and familiarize things while having fun and it is time consuming but the thing that students can learn from it while having fun playing with it is worth the time.

RECOMMENDATIONS

The data provides meaningful information to all stakeholders of education. Results of the study revealed that the created education board game have an effect in learning the concepts of periodic table of elements thus, there are some recommendations for improvements.

1. To use the educational board game created as a supplemental tool in teaching periodic table in chemistry subjects.
2. Rules and regulations of the created board game must be translated to layman's term for all players to understand the game mechanics clearly.
3. An addition of skills (Scientist/Chemist) can be added in order for a diverse choice of skill selection as well as for the game to be accessible to a wider range of audience.
4. The game mechanics can be improved in order to integrate higher order thinking skills not just knowledge development.

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