Effects of Manipulative Game-Based Learning on Students' Achievement in Chemistry

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This study aimed to determine the effects of Manipulative Game-Based Learning (MGBL) on students' achievement in Periodic Trends in Chemistry. The study involved 62 ninth graders from two sections of the Science, Technology, and Engineering (STE) track in a public high school in Quezon City. One section was used as the control group with a traditional teaching approach while the experimental group was taught using games and concrete manipulatives. The questionnaire was developed, pilot tested and validated by experts. The pretest and post-test scores were gathered, tabulated, and analyzed. Using an independent sample mean and paired t-test, results revealed that there was a significant difference in the post-test mean scores of the students who underwent Manipulative Game-Based Learning (MGBL).
The findings indicate that MGBL helped improve the knowledge and conceptual understanding of the learners. This is further supported by the respondents' feedback that they became active in class, showed more interest in the lesson, and created meaningful knowledge from the lessons. Researchers may explore using the MGBL in other topics of Science and discipline in different groups. Succeeding studies may tap on more variables and cover a large sample size to improve the study.

Keywords: *manipulatives, manipulative game-based learning, periodic trends, students' achievement, traditional teaching*

Introduction

Nowadays, students are preoccupied with social media applications containing various contents for entertainment rather than providing knowledge for learning. The time spent on social media applications of students increases while they become demotivated to focus on studying modules and learning materials leading to the imbalance of task breakdown between online and academic activity, sacrificing the latter (Rithika & Selvaraj, 2013). Aside from social media, unequal access to educational gadgets, shortage of instructional materials, and classroom inadequacy are some of the basic education challenges in student learning. These circumstances pose a threat to students' learning in science education and related fields.

Teachers need to be creative in delivering lessons to capture learners' engagement and assess the knowledge and understanding of the content. Innovative approaches in education are essential to support and assess the learning of the students, especially since nowadays educational literacy is an indicator of a country's success in economy, technology, and development. Based on the result of Trends in International Mathematics and Science Study (TIMSS) in 2019, the country obtained the lowest position of 58 out of 58 in primary science with no participation in high school science (Mullis et al., 2020). This is consistent with the data of the Programme for International Student Assessment (PISA) in 2018, where the Philippines ranked second lowest in science among the 79 countries (Paris, 2019).

Critical learning, being creative, and problem-solving are important 21st-century skills that students need to hone for better retention and learning. These skills are honed for the students to adapt and cope with upward changes in mathematics and science education. In Chemistry alone, most topics are considered by most students as difficult to learn. According to Cardellini (2012), the students do not learn Chemistry because the subject is seen as complex, symbolic, and abstract. The most common students' misconceptions about the subject are the arrangement of atomic radii in the periodic table and the group trends because of the periodic trends' abstract ideas, technical terms, and content that are difficult to grasp (Salame et al., 2011).

Educators are finding ways to make the topics simpler by splicing each topic and giving the students different analogies to aid their understanding. One promising strategy to develop 21st-century skills is through game-based learning. Educational games, considered as one of the most useful pedagogical designs, are injected into classroom learning over the years (Ferreira et al., 2016). Game-based learning is defined as the games and their elements containing the content, subject, and images often integrated into the process of learning. The game elements are incorporated in the learning process known as gamification (Ge & Ifenthaler, 2018). Gamification is an innovation that is still being developed. It promotes student engagement when applied in the classroom setting (Al-Azawi et al., 2016; Cozar-Gutierrez & Saez-Lopez, 2016). Game-based learning can be in a digital form that uses computer-mediated devices or non-digital forms such as manipulative materials like board games, cards, and other tangible materials in the classroom.

There are studies that argue that manipulatives have no clear edge over traditional teaching (Grupe et al., 1996; Uttal et al., 1997). Other studies indicate that students take time to acquire the concept and thorough application is needed for the manipulatives to be effective (Ball, 1992; Fuson & Briars, 1990). While the use of concrete manipulatives has significantly helped students in achieving mastery in Mathematics, only relatively few studies are conducted in science conceptual understanding (Kabel et al., 2021; Pratt & Eddy, 2017). As Hadji Abas and Marasigan (2020) point out, the lack of science equipment and the knowledge of using them and shortage of learning materials remain a challenge in conducting science laboratory activities in school. Thus, in this study, the use of games and concrete manipulatives is considered a potential approach in science teaching. Since game-based manipulatives are tangible, durable, and ready to use, they are preferred by teachers. Additionally, the use of game-based manipulatives allows the teacher to be flexible in offering variety in instruction. Moreover, the insertion of games and manipulative materials serves as a tool in learning science concepts (Osman & Sukor, 2013).

This research used two sections from Grade 9 consisting of 31 students each. The research investigated if there was a difference between the academic achievement scores in the pretest and post-test of the controlled group and the experimental group, based on the usage and non-usage of manipulative materials during instruction in a science lesson, specifically in periodic trends. This study also aimed to discover the effect of manipulative game-based learning (MGBL) on students' achievement in periodic trends in Chemistry and to determine whether this form of educational strategy would be an effective instructional method for Filipino learners.

Literature Review

Periodic Trends and Student Learning

Chemistry is one of the hardest subjects in Science because it covers topics such as periodic trends that involve numbers and problem-solving. Periodic trends are the patterns of elemental data in the periodic table of elements (Osman & Sukor, 2013). These topics are presented in graphs and charts for easier understanding, but most students lack the ability to read and interpret the data thus leading to memorization and confusion of the basic concepts (LeSuer, 2018). As such, periodic trends are relayed and simplified to transfer the knowledge to the learners. One study by Hoffman and Hennessy (2018) implemented a kinesthetic activity using students as elements in the periodic table and they assert that the attention of students increased, understanding of the lesson deepened, and the knowledge on periodic trends is applied to the subject. Moreover, Selco et al. (2013) indicate that the use of a tennis ball as representation of a simple atomic model helps the students to stimulate their visual thinking and clarifies the connection of elements location and arrangement in the periodic table. Thus, periodic trends as a topic, was chosen for this study to see if the lessons would be simplified and help the students possess conceptual understanding.

Manipulative Materials

Physical manipulatives such as model-making and simulation of physical materials are beneficial educational tools as they aid in learning abstract ideas. Manipulatives are interpreted as tactile objects used for hands-on teaching and learning (Carbonneau et al., 2012). Larkin (2016) has introduced perceptual manipulatives which refer to the objects that are concrete and accessible for experiential education such as sticks, blocks, chips, seeds, or even erasers. These perceptual manipulatives are found to be the most engaging in teaching and learning setup (Carbonneau et al., 2012).

The use of games and manipulative materials creates excitement and participation of students in the activity. They develop engagement, concentration, and interest. Montessori (1967) emphasizes that engagement is holistically involved in concentration, interest, and enjoyment. Concentration acquires depth in cognitive processing; interest engages the students in certain hobbies or subjects; while enjoyment is the positive or negative outcome of both. The study of Martin et al. (2014) puts forward that manipulative materials are advantageous to both students and teachers. The students are well-engaged in hands-on learning while the teacher implements the concepts with ease. In addition, the study of Moch (2002, as cited in Berkseth, 2013) reveals that longer exposures of students in manipulatives allow them to remember general facts and personal facts while improving theory retention.

In teaching, there is no perfect formula for students to learn the lessons effectively. Teachers always find a way to include new materials that are fun for the students. According to McNeil and Jarvin (2007, as cited in Berkseth, 2013), manipulative materials assist the students in both tactile learning and enhance cognitive thinking skills. Carbonneau et al. (2012) in their study, put forward that manipulatives improved the achievement of students in problem-solving in mathematics. In this manner, the manipulatives can be a potential tool if used in problem-solving and computation in Science such as Chemistry and Physics.

Despite the high praise of manipulatives, some studies discuss their unproductivity. One is the collective case study of Puchner et al. (2010) in which teachers tried to combine the manipulatives in the traditional method of teaching. After the implementation, teachers claimed that lessons were unsuccessful because of no change in students' scores and the representation of manipulatives did not translate to students' learning. Also, Hurst and Linsell (2020) used bundling sticks as manipulatives in arithmetic operations but found that it did not translate to mathematical learning. One reason for the ineffective application of manipulatives indicates that teachers relayed the manipulatives in a procedural approach rather than allowing the students to first explore on their own. Moreover, implementers presumed that manipulatives created mental representation for students, but they still had difficulty in conveying the knowledge and connecting the concept because of their dependency on the manipulatives (Hurst & Linsell, 2020).

Manipulatives, in the form of a game, are a good element to be included in the science classroom (Stiegelmeier & Moore, 2019). There are selected topics in Science especially in Chemistry which involve models and computations wherein manipulative materials and visuals are essential so that the representation and the transfer of knowledge are easily understood by the students. Manipulative materials such as concrete models can be derived based on the science concepts and symbolism that are hard for learners to understand. However, manipulative materials are only selective and specific to some topics based on their appropriateness and use. In choosing the manipulative materials, the basic and simpler ones are better (Laski et al., 2015).

Delaney (2010, as cited in Hurst & Linsell, 2020) argues that manipulatives are effective tools in teaching when the teacher demonstrates them together with the students. In using manipulatives, teachers must be aware of their purpose and objective, mechanics on how to use, and integrate the materials to the target subject. The mastery of the teacher on the manipulatives allows them to relay the knowledge to the learners while preventing misconceptions in the lessons. Before implementing the manipulatives, teachers must know the developmental abilities of the students, select age-appropriate manipulatives, and offer a collaborative learning environment to learners (Stiegelmeier & Moore, 2019).

Station-Rotation Strategy

The learning station rotation strategy used in the conduct of this research is considered one of the most important strategies that highly influenced active learning. In this research, the class was divided into smaller groups and each group worked on three stations where games were manipulated. Jonse (1997, as cited in Aqel & Haboush, 2010) describes this teaching method as "move and rotate" where every station is provided with educational materials and tools for an educational activity. Students are expected to move from one station to the next, look at images printed on paper, or read certain situations in the succeeding station. In station rotation, the entire class is divided into small groups and is involved in the activities by completing the tasks alternately.

Since the game-based manipulatives need more players and involvement of the group, station rotation is used to allow the students to join and have the chance to manipulate all the materials. Learning experiences in station-rotation are enhanced in the aspect of seeking help, performing different learning activities, and having fun while learning (Truitt and Ku, 2018). It also allows the students to establish rapport with their teacher and peers while their experiences increase when involved in different social activities (Govindaraj & Silverajah, 2017). Moreover, station rotation generates a positive increase in learning as different materials are provided for manipulation (Gil and Garcia, 2011). Additionally, in the study of Ceylan and Kesici (2017) among high school students, the use of station-rotation has a strong influence on the academic achievement of students in the comparison group. Similarly, Alsalhi et al. (2019) find out that it strongly influenced the science test scores of high school students.

Station rotation learning has benefits to both teachers and learners. It provides a wide array of materials to aid teachers during class discussion, thus, teachers can tap differentiated instruction among learners. Moreover, it offers flexibility so students can learn at their own pace (Mahalli et al., 2019). Staker and Horn (2012, as cited in Truitt & Ku, 2018) reiterate that station rotation enhances cooperative learning in a small group of learners.

However, learning stations have their limitations. One, they require ample time for planning. Second, they are costly. Third, they require close supervision of the class as they may cause unexpected chaos during implementation.

Game-Based Learning and Student Achievement

The game becomes educational when it serves its purpose in enhancing knowledge in subject areas or is used in training for cognitive thinking. Some of the core subjects that can benefit from the use of the manipulative game-based learning (MGBL) approach are science and mathematics subjects. In teaching science courses, utilizing educational models or assessment strategies that promote inquiry, collaborative, and cooperative learning is believed to be useful and operative.

Game-based learning and leisure have different goals in achieving their purpose. Game-based learning has an end purpose which enables the learners to assess how they learned from the game while leisure focuses on engagement and fun but is less concerned with the transfer of knowledge. Games are widely used as a learning tool of education and have been proven effective in the process (Annetta et al., 2010; Paraskeva et al., 2010). Games have the advantage of attracting students to participate in class discussion, aiding teachers in delivering the lesson with ease and creativity, and offering a new episode of class interaction occasionally. However, games must be taken with caution. According to Kim (1995, as cited in Afari et al., 2012), games are somewhat perceived as for fun alone and learning is not strengthened. Although, it is argued that games could tap both fun and learning when incorporated into the subject simultaneously.

According to Bragg (2007, as cited in Afari et al., 2012), most studies agree that games allow students to be more engaged and involved in activities. Through games, students enjoy competition and challenges with each other while having fun. Studies have demonstrated that learning motivation and efficiency can be enhanced through educational games (Knight et al., 2010; Liu & Chen, 2013). Educational models such as game-based learning can enhance students' confidence and participation towards the subject matter and learning achievement. Burguillo (2010) claims that game playing and group competition help increase the learning effectiveness of pupils. They also result in high motivation of pupils to learn the subject given to them. Ramani and Siegler (2011) compare the effectiveness of board games containing numbers played by students from the low-income and middle-class brackets. Results show that both groups achieved better performance in counting numbers and arithmetic. Furthermore, Bayir (2014) asserts that high school students and teachers who played board and card games gained knowledge in elements, compounds, and the periodic table of elements.

Locally, the study of Makalintal and Malaluan (2019) focuses on game-based learning activities for science educators. Based on their findings, science educators highly agreed that game-based learning activities are best implemented in the application process after the lesson is discussed and learned by students. Another study on gamified learning using the digital form as a teaching strategy reveals that the group of students belonging to the gamified class was found to be more motivated and driven in learning the subject (Malahito and Quimbo, 2020). Gamified learning also garnered positive feedback in instructional materials and tasking. Moreover, Pornel (2011) developed an educational board game for Mathematics and Statistics classes for young adults at the University of the Philippines-Visayas Campus. Based on the findings, 85% of the students who played the game once have enjoyed the game; 52% enjoyed playing more than once, and 14% were bored or uninterested. He also states that wordy instructions and limited variations of the game decreased the interest of students in playing the game.

Synthesis of the Reviewed Literature

Based on the literature, manipulative and game learning provide both promising and unfavorable results. The manipulatives and games are widely implemented in Mathematics to aid in counting, solving problems, and other number-related themes (Hurst & Linsell, 2020). Previous studies show that the use of manipulatives and games in Math improves test scores of learners and their mastery of concepts, and is effective in motivation (Hurst & Linsell, 2020; Laski et al., 2015). As the dynamics of the curriculum in the Philippines change, core subjects like Mathematics and Science are integrated based on their similarities on themes like problem-solving and computation. In the local setting, only a few studies on the use and effectiveness of manipulatives and games in science-related topics and themes can be found.

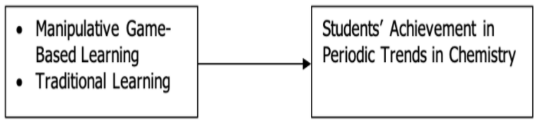
In this study, manipulatives and games are fused to create manipulative game-based learning as a tool applied in Science to help the students improve and gain knowledge in periodic trends in Chemistry. Periodic trends, as a topic of interest, are chosen because most students cannot identify patterns and arrangement of elements based on its data. They are struggling with the relationship on the increase or decrease of the atomic size of elements, they often lack the literacy to understand figures and bar charts in the textbook, and a majority of them have a shallow understanding of the concepts of periodic trends (LeSuer, 2018; Osman & Sukor, 2013). Moreover, manipulative game-based learning is implemented in high school to prepare the students for the fundamentals of learning in Chemistry before they begin the tertiary level.

Conceptual Framework

This research investigated the use of a manipulative game-based learning approach as an alternative approach in teaching periodic trends in Chemistry. Figure 1 shows the conceptual framework of the study.

Figure 1

Conceptual Framework of the Study



In this study, the manipulative game-based learning approach was tested as an alternative instruction in Science, specifically the periodic trends topic in Chemistry. It was assumed that manipulative game-based learning would have a positive influence on the academic scores of students. The framework shows variables that were examined in this study. The independent variable was the method known as the manipulative game-based learning approach (MGBL). The manipulative game-based learning consists of three sub-instructional parts: presentation of the concept, rotation-station activity, and discussion. Presentation of concepts involves the content and knowledge of the topic in the class. Rotation-station activity utilizes the use of games and concrete manipulatives. Discussion highlights the student-led activity and sharing of knowledge regarding the topic. On the other hand, traditional teaching consists of lectures and note-taking. The lecture involves the teacher and students interacting in the classroom with a focus on the content of the textbooks. Students receive the information as discussed and obtained from the source while doing notetaking. The dependent variable of this study was the scores of students in periodic trends in Chemistry.

Statement of the Problem

Generally, this study aimed to examine the effect of manipulative game-based learning on students' achievement in periodic trends in Chemistry. Specifically, it sought to answer the following questions:

1. Do students exposed to the Manipulative Game-Based Learning approach (MGBL) have higher achievement scores in Chemistry compared to those who were exposed to the Traditional Learning approach (TL)?
2. Are games and manipulative materials useful tools in supporting students' learning of the periodic trends in Chemistry?

Hypotheses of the study

1. The achievement scores of the group exposed to the Manipulative Game-Based Learning approach (MGBL) are significantly higher than the group exposed to the Traditional Learning approach (TL).
2. Games and manipulative materials are useful tools in supporting students' learning of the periodic trends in Chemistry.

Method

Research Design

This research employed a quasi-experimental method. This method involves the recording, analysis, and interpretation of the present nature, composition, or processes of data gathered.
It determines the effect of the intervention before and after the conduct of the study (Loewen & Plonsky, 2016). This study also used descriptive statistics to obtain the mean scores or weighted mean to analyze the students' academic performance.

There were two intact classes involved in this study; one group was exposed to Traditional Learning (TL), the other group was exposed to Manipulative Game-Based Learning (MGBL).

The research design is represented as follows:

MGBL	A_1	X_1	$A_{1'}$
TL	A_1	X_2	$A_{1'}$

Where: A_1 = Pretest
$A_{1'}$ = Post-test
X_1 = Manipulative Game-Based Learning (MGBL)
X_2 = Traditional Learning (TL)

Research Sample

The respondents of this study consisted of sixty-two (62) Grade 9 students enrolled in a public high school in Quezon City, Philippines. Two sections were used as samples. All came from the Science, Technology, and Engineering (STE) track. They were chosen as the subjects of this study because selected topics in Chemistry were included in their curriculum. The test was developed by the researcher and validated by experts. Before the intervention, the test was administered to the two sections, and analyses using two-tailed independent samples t-test revealed that there was no significant difference between their means scores, signifying that these groups had comparable knowledge in periodic trends before the implementation of the intervention. Through a toss coin, one group was chosen as the control group while the other was assigned to be the experimental group.

Instruments

For the quantitative data, a 15-item multiple-choice test (see Appendix A) which served as the pretest and post-test assessment was used.
It tested students' knowledge of periodic trends in Chemistry, specifically atomic radius, ionization energy, and electronegativity. The said test was developed by the researcher, validated by experts in the field of Chemistry, and pilot tested to grade 10 students. The experts verified whether the items matched the knowledge and performance standards suited for the grade level and the curriculum. The test was piloted to the 10th graders of the same school since they had prior knowledge of the topic. The test results from pilot testing were

run using the Cronbach alpha formula and the items were trimmed down to 15 containing five for each topic in atomic radius, ionization energy, and electronegativity. The test was used by the researcher to determine the effect of the manipulative game-based learning approach on the learning of students of the periodic trends in Chemistry. The reliability of the instrument obtained a Cronbach alpha coefficient of 0.605. The Cronbach alpha value that ranges from 0.60 to 0.80 is moderate and acceptable (Daud et al., 2018). This is similar to the study of Saadati et al. (2010) which interprets the reliability coefficient ranging from <.50 as low reliability, .50 - .70 as moderate reliability, and .70 as high reliability. The alpha coefficient values indicate that the instrument is acceptable. Obtaining a higher score on the test denotes an increase in the students' knowledge of the periodic trends in Chemistry. Item scores were added up to compute the total score for each student.

Two instruments were used to gather qualitative data. A five-item survey was given to the MGBL students to evaluate the use of games and manipulative materials. To gain a better understanding of the students' experience in learning periodic trends using MGBL, a written interview was conducted. They were asked three open-ended questions (see Appendix B) which were given on the same day of their post-test.

Manipulative Game-Based Learning

This research involved the intervention known as Manipulative Game-Based Learning (MGBL) which consisted of three sub-instructional parts: presentation of the concept, rotation-station activity, and discussion.

The study lasted for twelve sessions which included the administration of the pretest, the lessons on periodic trends, and the administration of post-test, written interview, and short survey questionnaires. Each lesson lasted for fifty minutes including the review of previous lessons, the introduction of the topic, activity proper, and practice exercise. The concepts under the topics were introduced through recalling and linking the terms as encountered. If the terms were new to the class, students were guided by the teacher by giving them context clues.

After the concepts were introduced, rotation-station activities were performed in small groups. The rotation stations consisted of a variety of games and allowed the students to move from one station to another which were stationed in or outside the classroom. First, the room was divided into different learning stations. Next, the teacher gave the overall instruction per learning station. Third, each group of students was assigned to a specific learning station. Fourth, the students accomplished the task in their first station. Fifth, at the signal of the teacher, the groups transferred to the next station. The activity was done once all the groups visited all stations. Each learning station could be done individually, by pair, or by group with the facilitation of the teacher if questions or clarifications arose.

Some of the games with manipulative materials are snakes and ladders, pin and chips, and modified BINGO cards for integrative topics of atomic size, ionization energy, and electronegativity. The snakes and ladders covered the topics of atomic size, pin and chips was for the ionization energy and electronegativity topics, and the modified BINGO game was used for the atomic size, ionization energy, and electronegativity topics. An overall review game for the class was also conducted which served as a review summary of all the lessons covered.

In the snakes and ladders game, each group was divided into two. Each member rolled the dice and the group with the highest total number started the game. Each group took turns navigating the game. The first group to answer the question correctly started the game using a token. Questions were categorized into three: easy for snakes, medium for regular moves, and hard for a ladder. The set of questions was organized and placed in an envelope. A member who landed exactly at the bottom of the ladder climbed up if they answered the question correctly. The next person who landed on the same spot had the chance to answer the previous question that was not answered. If the member landed on the top of a snake, the member proceeded if they answered the question correctly;

an incorrect answer meant sliding down. The next person who landed on the same spot had the chance to answer the previous question. If the person was on a spot without a ladder or snake, the person answered a regular question to proceed with the game. The winner was declared once a player reached the exact end number.

In the pin and chips game, a set of chips with written elements was given to each group. The chips were shuffled and the players were asked to arrange them correctly. The periodic table of elements served as the map to find the clue for the next mission. This game was timed, so failing to figure out the answer meant that the game was over.

In the modified BINGO game, each member of the group had a bingo card. The facilitator called out the terms, name of the element, and its corresponding symbol, the corresponding electronegativity of each element, and questions related to the lessons. If the student matched the corresponding terms or questions, they covered the card using chips or an erasable marker. If the student covered it diagonally, across a row or a column, they shouted BINGO. The facilitator double-checked and verified the winner of the game.

During the discussion stage, each group was given five to ten minutes to discuss the activity and how they incorporated the games into the lesson. This stage served as a sharing part to determine the feedback of students and room for improvement regarding the lesson.

Table 1 shows the comparison between the Traditional Learning Approach and the Manipulative Game-Based Learning Approach.

Table 1

Comparison between Traditional Learning Approach and Manipulative Game-Based Learning Approach

Sessions	Traditional Learning (TL) group	Manipulative Game-Based Learning (MGBL) group
Session 1	Pilot testing with the 10th graders and building rapport with ninth-grade classes	Pilot testing with the 10th graders and building rapport with ninth-grade classes
Sessions 2-3	Pretest administration, groupings, introduction of the topic outline and lesson	Pretest administration, groupings, introduction of topic outline and lesson
Sessions 4-5	Motivation activity, introduction of the concept in atomic size, note-taking, lecture, and discussion	Motivation activity, introduction of the concept in atomic size, use of snakes and ladders
Sessions 6-8	Review of the previous lesson, introduction of the concept in ionization energy, note-taking, lecture, and discussion	Review of the previous lesson, introduction of the concept in ionization energy, use of pin and chips
Sessions 9-11	Review of the lesson, introduction of the concept in electronegativity, note-taking, lecture, and discussion	Review of the lesson, introduction of the concept in electronegativity, use of modified BINGO
Session 12	Post-test administration	Post-test administration and answering the short survey and written interview

Data Analysis

The data collected were treated and analyzed using the Statistical Package for the Social Science (SPSS) software. All the hypotheses of this study were set at a 0.05 level of significance. The 0.05 is the threshold and reasonable value, set on the level of significance to determine whether the hypothesis of the study is accepted or rejected (Wasserstein & Lazar, 2016). Inferential statistics such as t-test of independence and paired sample t-test were used in this study. A two-tailed independent sample t-test was used for analyzing the pretest scores of the control and experimental group. A one-tailed independent sample t-test was used for analyzing the post-test scores of the control and experimental group to determine the changes between the mean scores of the two independent groups (Wasserstein & Lazar, 2016). Paired sample t-test was used for analyzing the pretest and post-test mean scores within the group. Lastly, qualitative data analysis of the students' responses to the short survey and the written interview was done to further shed light on the quantitative data.

Discussion of Data and Results

Effect of Manipulative Game-Based Learning on Students' Achievement in Periodic Trends in Chemistry

Table 2

Independent Sample t-test of Pretest Mean Scores of TL and MGBL Groups in Periodic Trends in Chemistry

Measure	Group	Mean	SD	N	t	p (one-tailed)
Pretest	TL	31.4194	8.6670	62	-.682	.498
	MGBL	29.2581	15.3752			

Table 2 presents the samples t-test of pretest mean scores of TL and MGBL group. Results showed no significant difference between the pretest mean scores of the TL and MGBL group, $t(62) = -.682$, $p = .498$. As shown in the table, the MGBL group had a lower pretest mean score ($M = 29.2581$), close to the pretest mean score of TL ($M = 31.4194$). This implies that the two groups were comparable prior to the intervention.

Table 3

Independent Sample t-test of Post-Test Mean Scores of TL and MGBL Groups in Periodic Trends

Measure	Group	Mean	SD	N	t	p (one-tailed)
Post-test	TL	52.7097	15.0890	62	4.274	.000***
	MGBL	67.5806	12.1512			

****p < .001*

As presented in Table 3, the results of the samples t-test showed a significant difference between the post-test mean scores of the TL and MGBL group, in favor of the latter. Students who underwent manipulative game-based learning had higher post-test scores ($M = 67.580$, $SD = 12.1512$) than the students in the TL group in general, $t(62) = 4.274$, $p = .000$. The result indicates that the intervention group showed an increase in scores after the test was administered during the conduct of the study. This implies that after the intervention, the MGBL group showed an increase in scores over the course period of the study.

This result suggests that the intervention aided the students to perform well in periodic trends. One of the explanations given by the students for their improved understanding was their ability to contextualize the concepts of the lessons through manipulative game-based learning. Additionally, the students reported that lessons become relatable if they were able to experience it firsthand as the teacher demonstrated it. Moreover, students became creative in taking part in the learning and the game, while enhancing competition between and among them as they looked for ways on how to win the game. This result is supported by the findings of Salame et al. (2011) that indicate that when the learners form their realization, they understand the concepts more. Sabourin and Lester (2014) also claim that in an environment where game-based learning is present, students' learning is engaged and enhanced. Likewise, Admiraal et al. (2011) assert that the students learned more if they were engaged in group games and activities.

Comparability of Within-Group Scores of Students' Knowledge of Periodic Trends in Chemistry

Table 4

Paired Sample t-test of Traditional Learning (TL) Group and Manipulative Game-Based Learning (MGBL) Group in Pretest and Post-Test Mean Scores in Periodic Trends in Chemistry

Group	Measure	Mean	SD	Mean Difference	N	t	p (one-tailed)
TL	Pretest	31.4194	8.6671	21.2903	31	-6.237	.000***
	Post-test	52.7097	15.0890				
MGBL	Pretest	29.2581	15.3752	38.3225	31	-13.323	.000***
	Post-test	67.5806	12.1512				

****p < .001*

Table 4 displays the pretest and post-test mean scores in periodic trends in Chemistry of the participants before and after the intervention period. As shown in the table, TL has a higher post-test mean score (*M* = 52.7097) than its pretest mean score (*M* = 31.4194). The result also indicates that the mean difference between the two paired samples of TL is (*M* = 21.2903). These figures show that the TL group had an increase in score in their post-test after the intervention period.
The statistical analysis showed that there is a highly significant difference between these mean scores *t* = -6.237, *p* = .000. This result suggests that the knowledge of students in periodic trends who were exposed to Traditional Learning significantly improved.

Comparably, the Manipulative Game-Based Learning group showed almost the same trend in terms of scores with the Traditional Learning group. It can be observed that the MGBL group had a higher post-test mean score (*M* = 67.5806) than the pretest mean score (*M* = 29.2581). The result also indicates that the mean difference between the two paired samples of MGBL is (*M* = 38.3225).
As presented in the table, the MGBL group showed an increase in score in their post-test which was administered after the intervention period.
The statistical analysis shows that there is a highly significant difference between these mean scores *t* = -13.323, *p* = .000. This result suggests that the knowledge of students in periodic trends exposed to the Manipulative Game-Based Learning group improved.

Comparing the two groups in terms of mean difference, it is noticeable that the MGBL group's mean difference (*M* = 38.3225) was almost two times higher than that of the TL group (*M* = 21.2903). In addition to that, by looking at the mean scores of TL and MGBL in their post-test scores, findings suggest that both groups had a positive change in their knowledge of periodic trends in Chemistry. The significant changes show that students from the Traditional Learning group and Manipulative Game-Based Learning group both attained higher post-test mean scores.

Similarly, considering the p-value, the results of both groups were significant and there was strong evidence that those who had undergone the intervention had higher post-test scores. This means that the difference in mean scores is significant enough to prove that there was a change after the intervention.

Relating to the abovementioned result, Lin et al. (2012) agree that manipulative game-based materials support the process of learning inside the classroom. Manipulative materials also enhance cooperative learning and friendly competition among peers. To reinforce the learning and engagement of students in a subject matter, teachers must integrate interactive materials. Hurst and Linselll (2020) indicate that manipulatives are sufficient in developing conceptual understanding regardless of the subject. Enki (2014) reiterates that student enjoyment is different when they are engaged in games and hands-on experiences. When the students enjoy the classroom activity, it directly affects their overall academic success positively with the proper facilitation and assistance of the teacher. In general, most of the research has shown evidence that proper usage of manipulative materials brings a positive effect on students' academic performance.

Games and Manipulative Materials as Useful Tool in Learning

Based on the responses to the written interview, among the three topics covered on periodic trends in Chemistry, MGBL students found ionization energy as a topic in periodic trends that was confusing and difficult to understand. Hence, aid was needed for them to learn the topics. Additionally, students were asked which way they learned and understood the topics well.
They responded that the game-based approach and manipulative materials stimulated and encouraged them to learn. They said that playing manipulative materials such as cards and board games made the lesson fun and enjoyable to learn.

Table 5

Responses of Students on the Evaluation regarding the Use of Games and Manipulative Materials

Statement	Strongly Agree (SA)		Agree (A)		Disagree (D)		Strongly Disagree (SD)	
	F	%	F	%	F	%	F	%
1. The activity/game was fun.	13	52.0	12	48.0	0	0.00	0	0.00
2. The instructions were direct and clear.	13	52.0	12	48.0	0	0.00	0	0.00
3. The content was well-supported by manipulative materials.	15	60.0	10	40.0	0	0.00	0	0.00
4. The materials provided were helpful in comprehending the topic.	17	68.0	8	32.0	0	0.00	0	0.00
5. The lesson became easily understandable with the use of manipulative materials.	15	60.0	10	40.0	0	0.00	0	0.00

(N = 25)

Table 5 shows the frequency of responses of students to the survey questions relating to games and manipulative materials. Twenty-five students from the experimental group answered the survey questionnaire. The survey was only given to the experimental group to assess the intervention. The reflected sample size was based on the student's discretion to participate in the survey. Based on the result, the highest frequency is item 4 with 68%, followed by items 3 and 5 with 60%, and lastly, items 1 and 2 got the lowest frequency of 52%. This implies that most of the students strongly agreed that manipulative materials aided in learning the lesson on periodic trends. Also, lesson content became stimulating and easily remembered when it was incorporated with games and manipulative materials. This is consistent with the study of Enki (2014) and Berkseth (2013) which maintain that students who were assisted with manipulatives were motivated to learn on their own and their attitude towards the subject was enhanced.

Implications

The use of manipulative game-based learning has implications for both learners and teachers. As it focuses on experiential learning, the manipulative game-based strategy/teaching is helpful in providing active processes and enhancing learning in Science. For learners, manipulative game-based instruction provides a learning space for students to explore hands-on activities, construct ideas on the topics, strengthen competition among peers, and have fun while learning. For teachers and educators, it allows them to adjust the pace of learning, it gives them the will to present visuals in the topic discussion, and provides supplemental materials for lesson enhancement.

Conclusion

Based on the results of the study, it could be concluded that:

1. There is a significant difference in the pretest and post-test mean scores in the Periodic Trends achievement test of students after being exposed to the Manipulative Game-Based Learning (MGBL). As a result of periodic trends instruction using manipulative materials, the experimental group improved their scores and showed more interest and enjoyment while learning. They also had a higher mean difference than the Traditional Learning group.
2. The implementation of Manipulative Game-Based Learning (MGBL) is a useful tool in aiding students' learning of Periodic Trends in Chemistry. The report of students showed that they were visibly more active in class, showed more interest in the lesson, and created meaningful knowledge in the lesson. This proves that the use of manipulative materials had a positive effect on students' academic achievement.

Recommendations

Based on the results and conclusion of the study, the following recommendations are put forward:

1. Larger sample size may be used to improve the research for more valid and reliable data and the test could also be improved by adding more items.
2. Manipulative Game-Based Learning (MGBL) can be used in selected topics in other subject areas in elementary or high school.
3. Future researchers may carry out a study of game-based manipulatives in elementary school Science.
4. Future researchers may tap on the comparative study between physical manipulatives and virtual manipulatives in science teaching.
5. Future researchers may conduct a study on the combination of physical manipulatives and virtual manipulatives using blended learning instruction.

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Appendix A

Periodic Trends Test

Name: ____ Score: ___________
Grade & Section: ______________________________ Date: ____________

Direction: Read and analyze each question carefully. Write the CAPITAL LETTER of your answer in the space provided. (15 points)

___1. What is electronegativity?
A. how large an atom is
B. the total negative charge of the electrons in an atom
C. how much energy is needed to take an electron away from an atom
D. how strongly an atom pulls electrons to itself when it is bonded to other atoms

___2. Which of the following best explains why ionization energy decreases down a group?
A. Ionization energy increases because electrons are closer to the nucleus.
B. Ionization energy decreases because electrons are closer and require more energy to remove.
C. Ionization energy decreases because electrons are further away and require less energy to remove.
D. None of the above

___3. Which has the *largest atomic radius?*
A. K B. K^+ C. Rb D. Rb^+

___4. Which has the *largest atomic radius?*
A. fluorine B. chlorine C. bromine D. a bromine anion with a charge of 1-

___5. Which has the *lowest ionization energy?*
A. beryllium (Be) B. strontium (Sr) C. calcium (Ca) D. magnesium (Mg)

___6. Which has the *highest ionization energy?*
A. phosphorus B. sulfur C. chlorine D. argon

___7. Which has the *highest electronegativity?*
A. Na B. Al C. S D. Cl

___8. Which has the *lowest electronegativity?*
A. F B. I C. Br D. Cl

___9. Element X belongs to Group 1. Which of the following best describes element X ?
A. high electronegativity
B. high ionization energy
C. low electronegativity
D. a non-metallic element

For numbers 10–14, use the periodic table below.

	IA																	VIII A
1	**H**	IIA											IIIA	IVA	VA	VIA	VIIA	**He**
2		**Be**	IIB	IVB	VB	VIB	VIIB		VIIIB		IB	IIB		**C**			**F**	
3				**Ti**		**Cr**					**Cu**		**Al**	**Si**				**Ar**
4																		
5	**Rb**														**Sb**			
6																**Po**		
7			**Lr**															

___10. In period 3, what is the best interpretation in the given data?
A. Atomic size increases from left to right within the period.
B. Ionization energy increases from left to right but atomic size decreases.
C. Ionization energy decreases from left to right but atomic size increases.
D. Ionization energy increases from left to right but atomic size also increases.

___11. Which element has the smallest atomic size?
A. Ar C. F
B. Cu D. H

___12. Which of the following elements have the greatest ionization energy?
A. Ar C. Cu
B. Cr D. Si

___13. Which of the following elements have the highest electronegativity?
A. Be C. F
B. C D. H

___14. Which of the following shows the correct trends of increasing atomic size?
A. Cr – Cu – Si – Ar
B. Ar – Si - Cu - Cr
C. H –Be – Cr – Rb
D. C – F – Cr – Cu

___15. What is the correct order of the elements in DECREASING ionization energy, given the set of elements: Na, S, Al, F, K, O?
A. Al, O, K, F, S, Na
B. F, O, S, Al, Na, K
C. K, Na, Al, S, O, F
D. Na, S, F, K, O, Al

Appendix B

Written Interview Questions for the MGBL Group

Explain your answer in 2-3 sentences.

1. Which among the topics in periodic trends do you like the most? Why?
   (*Aling paksa sa periodic trends ang pinakagusto mong pag-aralan? Bakit?)*

____
____
____
____

2. Which among the topic(s) in periodic trends is/are not clear to you? Why?
   (*Aling paksa sa periodic trends ang hindi pa malinaw sa iyo? Bakit?)*

____
____
____
____

3. In what ways have you learned and understood the topics in periodic trends (very well)?
   (*Sa paanong paraan mo mas natutunan at naiintindihan ang mga paksa sa periodic trends?*

____
____
____
____

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