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Learning Difficulties in High School Chemistry: The Case of Chemical Equilibrium

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Abstract. Chemistry is considered as an importance science for understanding various phenomena in nature and it is also the base for learning other sciences. However, many students across the world are facing difficulties in learning chemistry, especially chemical equilibrium topic. This academic article reports some problems and obstacles of teaching and learning chemistry at the high school level. Students' difficulties in learning as well as teaching and learning methods for improving students' learning and conceptual understanding of chemical equilibrium are described.

Keywords: Chemical equilibrium, chemistry learning difficulty, high school chemistry

THE NATURE OF CHEMISTRY

Chemistry has played a key role in understanding various processes and phenomena in nature. Because of chemistry topics are based on the science of the composition, structure of matter, properties, and the reaction of the substances. Chemistry curricula were astonished to find that many abstract concepts, which are central to further learning in both chemistry and other sciences (Taber, 2002). The nature of chemistry exists on three levels consisting of the macroscopic level refers to the observable phenomena with the naked eye (Johnstone, 2000). At the submicroscopic level refers to the nature, arrangement, and motion of molecules used to explain properties of compounds or natural phenomena. At the symbolic level refers to the symbolic representations of atoms, molecules, and compounds, such as chemical symbols, formulas, and structures (Bradley & Brand, 1985). The three levels interconnected between these representations (see Figure 1), which can lead to an internal conflict between students. Furthermore, students have difficulties in understanding relating chemical phenomena and concepts that do not result only from the existence of these three levels or from their explanation using abstract concepts, but also from the lack of interconnection between these representations. These representations are invisible and abstract while students' understanding of chemistry relies heavily on sensory

information. The ability of students to understand the role of each level of chemical representation and to transfer from one level of another are an important aspect of generating understandable explanations (Treagust et al., 2003). Therefore, educators employing design research to support secondary-level chemistry students' meaningful chemistry learning and higher-order thinking regarding ideas of chemistry.

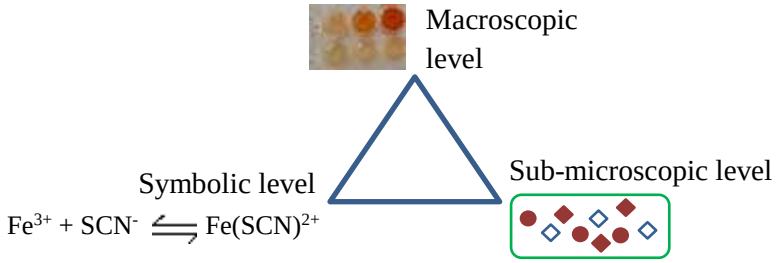

Figure 1: Three levels of chemical representation of the chemical equilibrium.

LEARNING DIFFICULTIES IN HIGH SCHOOL CHEMISTRY

Most difficulties as well as problems and obstacles in teaching and learning chemistry at the high school level are: (1) students did not have enough experience conducting chemistry experiments, (2) traditional experiments did not provide students a chance to carry out a variety of practical experiments, and (3) students did not develop conceptual understanding (Tamuang et al., 2017) Moreover, costs of chemical reagents and equipment have been increased so teachers solve problems using a virtual laboratory or try to reduce the number of laboratory activities to reduce costs. Furthermore, some teachers made changes to their teaching methods by substitution teaching the theory to practice experiments. In addition, the teachers may demonstrate the experiment without student participation.

Chemical education researchers have been trying to propose the teaching and learning approaches that enable students to improve their conceptual understanding of the chemical phenomena. Furthermore, employing design research to support higher-order thinking regarding ideas of chemistry (Aksela, 2005). Besides, teachers might plan to have students effectively interact with their knowledge in the laboratory and apply for daily life. Traditional instruction seems to unsuccessful in enhanced students. Therefore, a new approach to teaching and learning centered on students and their needs has become indisputable for education. Students construct their own understanding and knowledge, through the operation by themselves, problem-solving, and conclusion. Especially, encouraging students to use the chemical experiments or hands on activities to create more knowledge and then students were given sufficient time and opportunities for interaction and reflection. The learning environment emphasized, which can result in enhanced understanding and critical thinking skills. Also, the attitudes toward science, cooperation, and communication skills are intensified (Hofstein & Lunetta, 2004).

CHEMICAL EQUILIBRIUM

Learning chemical equilibrium is important for the chemistry. In the chemistry curriculum, equilibrium is considered as the basic chemistry concepts for senior high school students. Chemical equilibrium refers to a state with equal rates of the forward and reverse reactions. It is a dynamic process in which the reactant and product concentrations are constant, while the conversions between reactants and products are still in progress (Johnstone, 2000; Taber, 2002). Chemical equilibrium especially equilibrium constant (K_c) in particular is one of the most difficult topics in chemistry since it involves many factors that can influence the equilibrium and mathematical calculation (Aksela, 2005; Bradley & Brand, 1985; Treagust et al., 2003). Moreover, it requires an understanding of macroscopic, microscopic and symbolic natures (Hofstein & Lunetta, 2004) and the

dynamic nature of equilibrium or the equilibrium law devised by Le Chatelier (Birch & Stickle, 2003). Many students across the country experience these difficulties as revealed in previous studies, i.e., India (Banerjee, 1991), the USA (Voska & Heikkinen, 2000), Australia (Treagust et al., 2003), Thailand (Kajornklin et al., 2020; Tamuang et al., 2017) and Türkiye (Özmen, 2008). The definition of the equilibrium constant (K_c) is given as 'the ratio of the equilibrium concentrations of products over the equilibrium concentrations of reactants each raised to the power of their stoichiometric coefficients' (Johnstone, 2000; Taber, 2002).

TEACHING METHODS TO IMPROVE STUDENTS' LEARNING OF CHEMICAL EQUILIBRIUM

Several effective activities have been developed to enhance students' experience and understanding of chemical equilibrium as shown in Table 1.

These include, hands-on activities (van Driel et al., 1998), analogies (Thomas & Mcrobbie, 2002), demonstration (Akkuş et al., 2003) and laboratory experiment (Bilgin & Geban, 2006; Doymus, 2008; Maia & Justi, 2009), etc. Many of these activities, however, have a disadvantage in that they are mostly performed on a traditional scale and method with high-cost and insufficient scientific instruments making them unsuited for classes especially at a high school level. On the other hand, small-scale experiments (Figure 2), i.e. small-scale experiment (Tamuang et al., 2017) on a well plate and screen-printed paper-based device (Kajornklin et al., 2020) could diminish these limitations. The laboratory experiment is considered as one of the most effective activity in promoting students' visualization and conceptualization of this topic as well as engagement during the class (Aksela, 2005; Maia & Justi, 2009). Many laboratory experiments can promote students' conceptual understanding of equilibrium; however, they are often not suitable for the educational context of many schools and some universities due to limitations of access to reliable scientific instruments (Maia & Justi, 2009). Hence, alternative experiments using inexpensive facilities, quick process, and easy to carry out are highly advocated.

(a) Tamuang et al. (2017) (b) Kajornklin et al. (2020)

Figure 2: Small-scale experiment on a well-plate (a) and screen-printed paper towel-based experimental device (b).

In the field of chemical equilibrium, researchers show similar trend of misconceptions. These misconceptions include the approach to chemical equilibrium, characteristics of chemical equilibrium, the conditions of change in chemical equilibrium as well as predicting the conditions of equilibrium, the distinction between the conditions that characterize completion and reversible reactions, and the impact of factors on the value of the equilibrium constant. The topic of chemical equilibrium is unique because when teaching the misconceptions may occur due to the similarity with everyday experience as well as the abstractness of this phenomenon. Herein, we will focus more on the teaching of the concepts of chemical equilibrium. Therefore, we have developed a

simple and direct method to fabricate paper-based microfluidic devices that can be used for demonstrating a lot of alternative conceptions on chemical equilibrium.

Table 1: **Reports of previous research studies on chemical equilibrium**

Title	Teaching methods	References
Developing secondary students' conceptions of chemical reactions: the introduction of chemical equilibrium	Teaching strategies which promote conceptual change	van Driel et al. (1998)
Collaborating to enhance student reasoning: Frances' account of her reflections while teaching chemical equilibrium.	Constructivist approach	Thomas & Mcrobbie (2002)
Effectiveness of instruction based on the constructivist approach on understanding chemical equilibrium concepts.	Constructivist approach	Akkuş et al. (2003)
The effect of cooperative learning approach based on conceptual change condition on students' understanding of chemical equilibrium concepts.	Cooperative learning approach	Bilgin & Geban (2006)
Teaching chemical equilibrium with the jigsaw technique.	Cooperative learning (JIGSAW)	Doymus (2008)
Learning of chemical equilibrium through modelling-based teaching	Modelling-based Teaching	Maia & Justi (2009)
A teaching sequence for learning the concept of chemical equilibrium in secondary school education.	Teaching strategies which promote conceptual change	Ghirardi et al. (2014)
Investigating high school students' understanding of chemical equilibrium concepts.	Demonstrations, animations, & problem solving	Karpudewan et al. (2015)
Implementing an equilibrium law teaching sequence for secondary school students to learn chemical equilibrium.	Trial-and-error approach.	Ghirardi et al. (2015)
A colorful demonstration to visualize and inquire into essential elements of chemical equilibrium.	Demonstration	Eilks & Gulacar (2016)
A new multimedia application for teaching and learning chemical equilibrium.	Self-learning mediated by the use of multimedia animation	Ollino et al. (2018)
Geometrical description of chemical equilibrium and Le Châtelier's principle: Two-component systems.	Graphical presentations	Novak (2018)
Development of Chem in Action instructional media based on drill and practice in chemical equilibrium material for students in senior high school	Drill and practice	Masruroh & Diniaty (2020)
Demonstration of the factors affecting chemical equilibrium and chemical equilibrium constant	Paper towel-based experimental device	Kajornklin et al. (2020)

CONCLUSION

Chemical equilibrium is considered as one of the key concepts in chemistry since it relates and affects some chemistry topics such as chemical kinetics or chemical reaction rate. However, the chemical reaction has been found to be difficult to understand for high school as well as college students. These difficulties arose from many obstacles and complexity of this topic since it involves all three levels of chemical representation, lack of link among these representations, and requires some mathematics calculation. To understand chemical equilibrium meaningfully, students should have a chance to experience macroscopic information from practical experiment, explain it by using stadard symbolic explanation, and then link these data to what is happening at the intangible submicroscopic level. Many teaching and learning methods can be used to improve students' learning and conceptual understanding of this concept. The small-scale experiments that can be implemented under a normal high school classroom context are highly advocated since it is low-cost, less time requirement, portable, convenient and easy to perform by high school students. This type of experiment has been proven to be effective for enhancing students' conceptual understanding not only the chemical equilibrium, but also other chemistry topics as reported in many scientific journals.

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ATP (Adenosine triphosphate) Quest: Board Game on Cellular Respiration for Face-to-Face and Remote Learning

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Abstract. The demand for novel way of learning complicated science concept is a constant challenge and this study addresses the issue by developing a modality that can be versatile as lesson support, supplement, and possibly a stand-alone learning delivery by letting them play and explore. The development involved three tryout and revision sequence with corresponding evaluation by experts. A usual summative assessment was given to students who have not yet taken, currently taking, and have already taken the topic. A measure of the incremental learning was measured using normalized gain, and intrinsic motivation was also measured after playing with ATP Quest. Results showed that in three types of learners, there is a good increment in their scores to the summative exam. Interestingly, there is no difference in the normalized gain for the three types of learners. Results lead the researchers to conclude that the ATP Quest can indeed engender learning even in the absence of formal instruction. That the game can be a good review for learners taking or have taken the topic. Above all, the game showed promise of applicability in remote and face-to-face learning.

Keywords: board game; normalized gain; intrinsic motivation; formal instruction.

INTRODUCTION

The 21st Century learners need a radical way of pedagogical approach as supported with the persisting learner proficiency across the curriculum but perhaps more emphasis on Science. Teaching method talks about the principles and pedagogical techniques used for classroom instruction. Educational philosophies, learners, subject areas and learning outcomes are integral parts in teaching methods. Thus, DepEd initiates the move towards utilizing learner-centered approach in teaching. Teaching methods can be teacher-centered approach or learner-centered approach. Teacher-centered approach is associated with traditional teaching, a method of teaching which focuses on the role of the teacher as the source of the learning environment and act as the main factor in such approach. This approach view students as "empty vessels", who passively receive the

knowledge from the teachers through lectures. Learner- centered approach is associated with authentic teaching methods in which the activities focus on the learners and not on teachers. This method takes account of active learning where students solve problems, answer questions, formulate questions of their own, and other skills that involve the higher order thinking skills (Felder, 2017). In addition, this method also incorporates authentic materials in the teaching-learning process. Authentic materials are esteemed as dependable representations of the topics which can help scaffold the students' understanding about the lesson. The use of authentic materials in the classroom is a useful means to motivate learners and arouse their interests about the topic at hand (Al Azri & Al-Rashdi, 2014). Development efforts in science education evinced a shift from the conventional classroom teaching to focusing on engaging students in authentic classroom activities incorporating authentic materials in the process (Ford & Wargo, 2007).

Extensive research in a variety of disciplines has proven that play is an important factor in a child's mental development. According to Verenikina (2008), when children play games, it does not merely mirror the level of cognitive development that has been attained, but it also fuses the skills, actions, and implications that have been assimilated. Play facilitates learning because it scaffolds an expansive zone of proximal development where children are performing tasks slightly above the capacity of their abilities (Vygotsky, 1967). A study conducted by Burguillo (2010) showed that incorporating game theory with the practice of friendly competitions provides incentive for students which can help to improve their performance. Twenty-first century education is more focused on these concepts of reinforcing learning to students. These methods focus on the critical areas of a student's set of skills namely; collaboration, creativity, critical thinking and problem solving. It is becoming more evident that learners in this generation are way more different from the learners in the first decade of the new millennium. These 21st century learners are highly adaptive to changes as they have grown up in the new digital landscape. Moreover, with the advent of technology, transformation is taking place in the education system.

For the last few years, it has been observed that one of the common problems encountered by students in studying Biology is the difficulty of understanding biological concepts. Terminologies used can be very complex which need to be concretized in order to full comprehend the lesson at hand (Gutierrez, 2014). One of these biological concepts is cellular respiration. Both Patro (2008) and Baines, McVey, Rybarczyk, Thompson and Wilkins (2004) agreed that cellular respiration is a particularly difficult topic for undergraduate Science teachers and students to discuss and comprehend. Many of the students who are unfamiliar with the topic were struggling in the memorization of details and terminologies rather than focusing more on the overall process and purpose of cellular respiration.

One effective way to further comprehend the lessons would be the application of games to improve the teaching-learning process. This refers particularly to the game-based learning (GBL). Game-based learning is created to equilibrate the subject matter with the board game and the abilities of the players (learners) to retain and apply the said subject matter to the real scenarios (EdTechReview, 2013). According to studies, students learn more satisfactorily by using games in the classroom and a board game is one of the good examples. A board game was explicitly designed to foster active learning environment wherein it provides an effective means of presenting a lesson most especially for the complex ones. Board games as a medium of teaching, enables students to practice collaboration, communication and develop problem solving skills in an interactive way (Pollanen & Vartiainen, 2011). Incorporating board games in the teaching-learning process is an effective way to improve critical thinking, to develop other set of skills such as problem solving and to allow the learners to freely analyze, plan and experience things in a way that they really love. With the use of board game in teaching, students are able to develop their hands-on and heads-on skills and knowledge about the subject matter. Well-designed games can help the students in the learning process by providing an engaging, non-threatening, yet competitive environment (Palisbo et al., 2016).

The researchers themselves find this topic difficult since the terms used were highly technical and the complicated concepts need to be familiarized. The means of discussing the topic is commonly traditional where teachers simply present the lesson deductively. Furthermore, the students can only rely on their imagination about the complicated concepts and processes of the topic since it lacks hands-on activities. The researchers believe that a board game can provide a graphic representation that will help students to link information which can develop not only their lower order thinking skills but also their higher order thinking skills. Only a few studies have been made in the Philippines and in the neighboring Asian countries regarding the use of board games in teaching biological concepts. Therefore, the researchers have developed a cellular respiration board game applicable to students with wide learning background. The developed board game was evaluated and tested for its effectiveness.

METHODOLOGY

This section presents the research design, research instruments, research respondents, data-gathering procedure and data analysis.

Research Design

This study followed the one-group pre-test-posttest design. In one-group-pre-test-posttest design, each participant was tested first under the control condition and then under the treatment condition. Thus, the dependent variable in one-group-pretest-posttest research design was measured once before the treatment was implemented and once after it was implemented. (Open Text, 2017).

Research Instruments

There were four sets of instruments used in this study. One was the developed board game itself. The second set was the board game rubric (see Appendix 1). This was adapted and modified from Palisbo et al. (2016) to evaluate the developed board game in terms of content, creativity and rules and instruction. The board game rubric was modified to fit to the study. This board game rubric was validated by one (1) expert in rubric construction. The third set was the activity perception questionnaire (see Appendix 2). This was adapted and modified from Deci, Eghrari, Patrick, and Leone (1994) to measure the activity perception of the student users of the game. The questionnaire was divided into two parts. The first part has three (3) dimensions: interest/enjoyment, value/usefulness, and perceived choice. The items that belong to the interest/enjoyment dimension were item 3, 5, 8, 10 and 14. The items that belong to the value/usefulness dimension were item 1, 4, 6, 9, 11, 12, 13 and 15. The items that belong to the perceived choice dimension were 2 and 7. The second part was intended to collect information from the student users that would help the researchers improve the developed board game. The fourth set of instruments was the researchers- made test to be administered before and after the topic was covered by the experimental group to determine the performance level of the students in Cellular Respiration in the pretest and posttest (see Appendix 3). This researchers-made test was validated by two (2) content experts in the field of Biology, one (1) expert in test construction, and one (1) expert in English grammar. The researchers developed a board game based on the famous game MonopolyTM. The game can be played by 3-5 players or 3-5 groups with a maximum of 5 members per group. A student would be assigned to be the moderator of the game. The players of the game would select a token of their choice and place their tokens on the corner marked “GO”. Each player would take turns in throwing the dice and the player with the highest total starts the play (Player 1), the next highest would be the second (Player 2), and so on.

To start the game, Player 1 would roll the dice and move his or her token to the corresponding box. Player 1 would follow the instruction corresponding the box. After Player 1’s turn, Player 2’s turn would come next, and so on. When a player lands in a Question box, the player would have to pick one question card under the category

indicated, read the question out loud, and answer the question given. If the player answered the question correctly, then the player would get the corresponding reward indicated in the card. A player can only steal the questions of other players if and only if the player has a Steal Chance card which can be obtained from drawing cards from the Test Your Luck cards. If ever there are more than one (1) player who wants to steal the question, they need to roll the dice and the player with the highest total would be the first one to steal the question. If the first player to steal the question cannot answer it, then the second player with the second highest total can have the chance to steal the question. Only two (2) players are allowed to steal the same Question card. If no one got the correct answer, the moderator would be the one to reveal the answer to the question. Only questions from Little Brain Exercise question box, Vigorous Brain Exercise question box, and Extreme Brain Exercise question box can be stolen, except for the True or False questions.

In answering the questions, the players would be given a maximum time of 5 seconds for answering the Little Brain Exercise questions and would be given 2 ATPs if they could answer the question correctly. For Vigorous Brain Exercise questions, the players would be given 10 seconds to answer and 3 ATPs and 1 NADH as the corresponding points. For Extreme Brain Exercise questions, the players would be given 20 seconds to answer and 5 ATPs, 1 NADH and 1 FADH as the corresponding points (see Appendix E).

For questions from Test Your Luck cards, when a player lands in Test Your Luck box, the player would pick one (1) Test Your Luck card and follow the instructions written in the card. If the player would pick a question in Test Your Luck cards, the player would have the chance to receive 5 ATPs, 1 NADH and 1 FADH as the rewards by answering the question correctly. The questions would vary in terms of difficulty. The player can choose to decline the offer of the question from the Test Your Luck card and if ever the player would decline the offer or is unable to answer the question correctly, the other players will have the opportunity to steal the question.

When a player lands in a landmark, which can be the mitochondrion or the cytoplasm, the player can trade his or her rewards in the said landmark with the corresponding amount of ATP that they can be exchanged with. When a player lands in the Lack of Oxygen box, the player would lose a turn and would have to give up one (1) ATP. As a player lands in the Drop by in the Matrix box and in the Just Visiting box, the player would do nothing and wait for their next turn. As a player passes by the box marked GO, the player would collect free two (2) ATPs. The teacher can set a time limit for the duration of the game, for instance having the game for only 20 minutes or so. The player who garners the most number of ATPs or the first to collect 36 ATPs wins the game. If ever there would be a tie, both players and groups would be declared as winners. The board game rubric employed a 4-point scale with four (4) being the highest.

2.3 *Research Respondents*

The research participants are the students from La Salle University-Night High School (LSU-NHS) during their fourth grading period and college students enrolled in Biological Science (NS103) classes of the second quarter lessons in the second semester of Academic Year 2017-2018 as indicated in the course outline provided by the Science Department of the College of Arts and Sciences. There are twenty-seven (27) students from NS10301 class, thirty (30) students from NS10302 class and twenty (20) students from NS10303. There are thirty-five (35) students coming from grade 7-Br. Bernadine, thirty-five (35) students from grade 8-Br. Andrew, forty-one (41) students from grade 9-Br. Crisanto and twenty-seven (27) students from grade10-Br. Edward from LSU-NHS. The total number of student participants was two hundred fifteen (215). The participants in each section were divided into 2 groups, each group consists of 4 subgroups consisting approximately of 2-6 participants each. To determine the participants of each group, random sampling by lottery was employed.

Data-Gathering Procedure

The researchers administered a pretest and posttest to each class. The pretest was given first to each class, after which, the researchers let each class to play the developed-board game. The participants in each section were divided into 2 groups, each group consists of 4 subgroups consisting approximately of 2-6 participants each. To determine the participants of each group, random sampling by lottery was employed and the researchers discussed the mechanics of the game.

While playing, it was very evident that all the student-participants in all classes were very participative, they're attentions were on the game when the game started and by the time the game ends thus, the participants were motivated. They always celebrate if ever they could answer the questions correctly through yelling and clapping their hands. It was very evident that all the participants really enjoyed the game and even the facilitators enjoyed the game as well.

After playing, posttest was given to each class, and then the activity perception questionnaire was given and followed by the rubric of the board game. This were checked and recorded for data analysis.

Data Analysis

Statistical tools were used to analyze the data with normalized gain which is used to measure the effectiveness of a course in promoting conceptual understanding (Hake, 1998), McNemar's test, a test on a 2x2 classification table used to test the difference between paired proportions, e.g. studies with "before and after" design (MEDCALC, 2018) and one-way ANOVA which used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups (Lund Research Ltd, 2013).

Thus, statistical analyses were carried out towards the success of this study. These includes McNemar's test, used to measure the effect of the developed-board game to the pretest and posttest performance of the students. Normalized gain was used to measure the effectiveness of the researchers-developed board game in promoting conceptual understanding of the topic cellular respiration for a consistent analysis over diverse student population with widely varying initial knowledge states and one-way ANOVA was then used to determine the significant difference in the normalized gains.

The researchers made fair and equitable judgments by ensuring accurate results on each statistical tool mentioned. This helped the researchers in determining the effectiveness of educational board game as a stand-alone material for cellular respiration.

RESULTS AND DISCUDDION

The result from the achievement test conducted by the researchers before and after the application of the board game which was participated by 215 students from LSU-Night High School and college students enrolled in NS103 (Biological Sciences) classes and results from the board game rubric and the Activity Perception Questionnaire answered by the participants after the game are shown in the following table.

Performance level of the students in cellular respiration and normalized gain.

The researchers sought to know the performance level of the students in cellular respiration and if there is a significant difference between the normalized gain of each group of students.

Table 1 Average Performance and Normalized Gain of Each Section of Students (N=215)

Section	Average Pretest Scores	Average Posttest Scores	Average Normalized gain
Grade 7 (N=35)	5.943	7.343	0.075
Grade 8 (N=35)	5.314	7.886	0.163

Section	Average Pretest Scores	Average Posttest Scores	Average Normalized gain
Grade 9 (N=41)	7.878	9.927	0.159
Grade 10 (N=27)	6.556	8.000	0.096
NS10301 (N=27)	6.667	9.815	0.218
NS10302 (N=30)	6.433	8.700	0.150
NS10303 (N=20)	6.800	8.800	0.135
Overall Mean	6.513	8.639	0.142

Table 1 shows the data results on the average performance level of the students in cellular respiration based on their pretest and posttest scores and its normalized gain. The students' average pretest and posttest scores are satisfactory at 6.513 (~7) and 8.639 (~9) respectively. Results show that the scores of the students increased when the average pretest scores are compared with the average posttest scores. This indicates that the board game is successful in improving the performance level of the students in cellular respiration. To test whether there is a significant difference among the normalized gain of each section, one-way ANOVA was used. At alpha level 0.05, the test showed that the P-value is 0.06478 indicating that there is no significant difference in the normalized gain among sections. The normalized gain between the four different grade levels from LSU-Night High School, and three sections from NS103 did not differ much from each other which is an indicator of a similar effect across grade levels with or without prior formal instruction. The results of the study are similar to the study conducted by Gauthier, Corrin and Jenkinson (2015) where they explored the influence of game design on learning. They suggested that game mechanics can encourage more specific problem-solving strategies than having only a study aid, leading to greater predictability of learning outcomes. Studies conducted independently by Viray (2016) and Jui-Mei, Chun-Ming, Hwang and Yueh-Chiao (2011) both revealed that the academic performance of students increased after being exposed to the board game. The results in the achievement test was in fact very low and that would entail revisiting the items, but the good side of the result is that the performance is the same for respondents whether they have taken the topic already or not. This implies that a board game has the capacity to impart learning, and this needs to be investigated further in the same topic, in other topics, and in other subject areas be it Science or not. There is also an interesting aspect as to what best mode the board game be used, as instructional tool, as review tool, or as standalone learning material like DIY.

Comparison of the pretest and posttest scores of the students per item.

One of the purposes of the study is to know if there is a significant difference between the pretest and posttest scores of the students per item in the achievement test. Table 2 presents the results below.

Table 2 Significant Difference between the Pretest and Posttest Scores of the Students per item

Item Number	Wrong before Wrong after	Right before Wrong After	Wrong before Right after	Right before Right after	P-value	Decision
1	139	3	58	15	<0.000001	Statistically significant
2	54	22	78	61	<0.000001	Statistically significant
3	34	15	80	86	<0.000001	Statistically significant
4	46	23	59	87	0.000087	Statistically significant
5	112	32	45	26	0.171061	Not statistically significant
6	72	24	53	66	0.001263	Statistically significant

Item Number	Wrong before Wrong after	Right before Wrong After	Wrong before Right after	Right before Right after	P-value	Decision
7	50	36	22	107	0.086949	Not statistically significant
8	82	31	61	41	0.002315	Statistically significant
9	67	32	80	36	0.000007	Statistically significant
10	121	35	42	17	0.494382	Not statistically significant
11	118	24	49	24	0.004626	Statistically significant
12	148	25	27	15	0.889884	Not statistically significant
13	94	39	57	25	0.082193	Not statistically significant
14	109	25	58	23	0.000378	Statistically significant
15	87	33	50	45	0.078420	Not statistically significant
16	69	33	71	42	0.000247	Statistically significant
17	83	44	36	52	0.434042	Not statistically significant
18	164	14	29	8	0.031539	Statistically significant
19	122	29	30	34	1.000000	Not statistically significant
20	116	40	34	25	0.561381	Not statistically significant

Table 2 shows the data recorded when the pretest and posttest of each student for each item was compared. McNemar's test was used to test whether there is a significant difference between the scores from the pretest and posttest scores of the students in each item after the application of the board game. The test showed that at alpha level 0.05, 55% of the test items have statistically significant difference while 45% of the test items has no significant difference between the pretest and posttest scores. Results suggest that after the application of the board game, by comparing the paired nominal data of the pretest and posttest, the students correctly answered many of the items after playing the board game. This implies that they have learned something after playing the board game. Just like in the study conducted by Palisbo et al. (2016), which supports that a board game has the capacity to enhance cognitive understanding about topics even without formal instruction.

Intrinsic motivation of the students after using the board game

One of the purposes of the study is to know the intrinsic motivation of the students after using the board game. Students were asked to respond on an activity perception questionnaire with a 7-point Likert scale. Table 3 presents the results.

Table 3 Average Intrinsic Motivation of the Students in Playing the Board Game (N=215)

Section	Value/ Usefulness	Interest/ Enjoyment	Perceived Choice
Grade 7	6.118	6.314	6.229
Grade 8	6.555	6.703	6.476
Grade 9	6.364	6.548	6.214
Grade 10	6.373	6.767	6.629
NS10301	6.363	6.631	6.423
NS10302	6.271	6.640	6.300
NS10303	5.764	6.310	6.283
Overall Mean	6.258	6.559	6.365

Table 3 shows the data results on the perception of the student participants to the board game activity in terms of the dimensions Value/Usefulness, Interest/Enjoyment, and Perceived Choice. Activity perception questionnaire is the measure of intrinsic motivation as respondents played the board game "ATP Quest." The questionnaire is a 7- point Likert scale and it turns out that the respondents have very high motivation. First is the dimension of Interest/Enjoyment with overall mean of 6.559. This element of enjoyment is crucial for learner to engage further in an endeavor in science (Ainley & Ainley, 2011; Bye,

Pushkar & Conway, 2007). Thus, if the board game enhances enjoyment, then learners will be interested to work on the material.

The next dimension is Perceived Choice with overall mean of 6.365, and this is identified as one of the general motivational constructs suspected as potential mediators towards conceptual change (Pintrich, Marx & Boyle, 1993). In this case, the board game contained this element of perceived choice that has something to do with control in the activity and can lead to the desired conceptual change that is learning.

The last dimension is the Value/Usefulness with overall mean of 6.258 which is identified as crucial stimulator for learners to continue pursuing a task (Chiu & Wang, 2008; Al Azri & Al-Rashdi, 2014).

The average of the overall mean of each dimension is 6.394 which means that the students perceived the board game activity as very interesting, useful and helpful in recalling and understanding the terms in the topic cellular respiration.

On the part 2 of the activity perception questionnaire, students were asked to answer two questions about their experience in using the board game. Students have left positive comments about the board game activity. Some students remarked that one of the best features of the game was that it can enhance self-focus, concentration and help them have a deeper understanding about the topic. A student stated that the game helped them develop their critical thinking skills and collaborative skills improving their teamwork. Other students said that they liked the questions in the game, especially the True or False questions, the most as it is comprehensive, and it really made them think about what they have previously learned about the topic and relate what they have already learned in order to answer the questions thrown at them helping them also to recall and remember their learnings from the past. The questions are also a bit challenging and they like that aspect of it. Many of the students commented that the best feature of the game was that it was fun and interesting to do. A student loved the experience because they are learning and at the same time, they are also having fun. A student also commented that the board game was somewhat new to her making the whole experience even more exciting.

Students also commented on the parts of the board game that needed improvement. Some mentioned that some of the questions, especially for the "Extreme Brain Exercise" questions, are very hard for them and that they cannot answer it. A student remarked that the time given for the whole duration of the game should be extended. Others mentioned about some parts of the mechanics that they wanted to be enhanced like the mechanics regarding the steal cards. Some stated that the tokens and the materials being used for the board game, like the quality of the chips for ATP, NADH and FADH2, need to be improved.

Perception of the students to the board game

One of the purposes of the study is to know the perception of the students to the board game in terms of its content, creativity, and rules and instruction. Students were asked to respond on a board game rubric. Table 4 presents the results.

Table 4. Perception of the Students on the Board Game based on Content, Creativity, and Rules and Instruction (N=215)

Section	Content	Creativity	Rules and Instruction
Grade 7	3.722	3.833	3.639
Grade 8	3.771	3.886	3.686
Grade 9	3.857	3.809	3.667
Grade 10	3.944	3.722	3.667
NS10301	3.846	3.808	3.577
NS10302	3.900	3.900	3.700
NS10303	3.650	3.650	3.450

Section	Content	Creativity	Rules and Instruction
Overall Mean	3.813	3.801	3.626

Table 4 shows the data results of students' perception on the board game based on content, creativity, and rules and instruction. Rubric was adapted and modified from Palisbo et al. (2016) to evaluate the developed board game in terms of content, creativity and rules and instruction. The board game rubric was modified to fit to the study. Based on the results, the participants perceived the board game as excellent in all three criteria. First is the content with overall mean of 3.813. This criterion is crucial for learner to engage further in an endeavor in science (Ainley & Ainley, 2011; Bye, Pushkar & Conway, 2007). Thus, if the board game enhances the knowledge of the students about the said topic, then learners will be interested to engage on the material.

The next criterion is creativity with the overall mean of 3.801. The rubric assessed the participants' perception of the creativity of the developed-board game about cellular respiration based upon the components described by Bisson and Luckner (1996). In this case, the board game contained these elements of art that have something to do with the principles of design applied to the board game, the construction of mechanics and the questions as well. Exposing students to such language forms will enable them to cope with genuine interaction, whether it is inside or outside the classroom (Widdowson,1990).

The last criterion is rules and instruction with an overall mean of 3.626 which is identified as crucial part of the board game as it indicates how the game will be played, if the rules and instruction are clear and very easy to follow. The average of the overall mean of each criterion is 3.746 which means that the students perceived the board game as an excellent board game in terms of content, creativity and rules and instruction.

Conclusions and Recommendations

The purpose of the study was to develop a board game applicable to students with wide learning background and assess its effectiveness as a stand-alone material in learning the topic cellular respiration.

1. The performance level of the students in cellular respiration in the pretest and posttest are both satisfactory having an overall mean of 6.513 (~7) and 8.639 (~9) respectively.

2. The average posttest scores ($\bar{x}$= 8.639) of the students are higher in comparison to their pretest scores ($\bar{x}$= 6.513).

3. One-way ANOVA showed that there is no significant difference among the normalized gain of each sections, having a P-value of 0.06478.

4. McNemar's Test revealed that 55% of the test items have statistically significant difference while the remaining 45% of the items have no statistically significant difference between the pretest and posttest scores.

5. The students' intrinsic motivation after using the board game is very high, with each dimension namely value/usefulness, interest/enjoyment and perceived choice having an overall mean of 6.258, 6.559 and 6.365 respectively.

6. The perception of the students to the board game in terms of content ($\bar{x}$ = 3.813), creativity ($\bar{x}$= 3.801), and rules and instruction ($\bar{x}$= 3.626) is excellent.

Based on the findings of the data gathered, the researchers conclude that the developed board game was effective in a sense that the performance level of the students has improved as shown in their higher posttest scores. From that academic improvement, students are more motivated to learn as they engage in the board game. Hence, it is through the developed board game that captivates students' attention in learning the topic cellular respiration in a relaxed and fun environment.

Considering the conclusions of this study, the following points are hereby recommended:

1. Addition of card game as preliminary game - The use of card game is to unlock difficult terms that the student would encounter during the game. Thus, the cards

will contain terms, definition and explanation; this would give the learners background knowledge.

2. More groups or players - The game must accommodate a large number of participants who want to play the game. In order to address the problem, the researchers would like to add more question boxes varying in difficulty.

3 . Lesson sequence with the developed board game as instructional support - The researcher would like to utilize the developed game as instructional material where it can be used as an activity in teaching Cellular Respiration or used as an assessment tool.

4. Student as the moderator of the game - Instead of having the teacher to be the moderator of the game, students should take the role as the moderator of the game. They are the ones taking control in giving the ATP, NADH, FADH, and act as the timekeeper as well to give emphasis that the developed game can be utilized as a stand-alone game that can be played even without formal instruction coming from the teacher.

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Appendix 1

BOARD GAME RUBRIC

This is the board game rubric adapted and modified from the work of Palisbo et al. (2016).

	Fair 1	Good 2	Very Good 3	Excellent 4	
Content	No factual information about cellular respiration is presented.	1-5 factual information about cellular respiration is presented.	6-10 factual information about cellular respiration is presented and factual.	All relevant information about cellular respiration is presented and factual.	
Creativity	The board game does not follow the principles of design, has mechanics and contains unnecessary questions.	The board game follows 1 or 2 of the principles of design, has innovative mechanics but contains unnecessary questions.	The board game follows 3 or 4 of the principles of design, has innovative mechanics and interesting questions.	The board game follows all the principles of design, innovative mechanics and interesting questions.	
Rules and Instructions	The rules and instruction provided are confusing and hard to follow.	The rules and instruction provided are a little bit confusing.	The rules and instruction provided are easy to follow.	The rules and instruction are very clear and very easy to follow.	
				Total	

Appendix 2

ACTIVITY PERCEPTION QUESTIONNAIRE

Congratulations, you have tried using the board game. Hence, the researchers would like to ask your experience from the task. This questionnaire is divided into two parts. Part 1 deals with the following items concerning your experience with the task. Part 2 is intended to collect information from the student users that will help the researchers improve the developed board game. Please answer all items. For each item in Part 1, please indicate how true the statement is for you using the following scale as a guide.

Part 1

1	2	3	4	5	6	7
not at all true			somewhat true			very true

1. I believe that doing this board game activity could be useful in understanding the concepts and terms in Cellular Respiration.
2. It is my choice to participate in this board game activity.
3. While I was doing this board game activity, I enjoyed it.
4. I believe that doing this board game activity is useful in improving concentration.
5. This board game activity was fun to do.
6. This board game activity is important for a Biological Sciences student like me.
7. I participated in this board game activity because I wanted to.
8. This board game activity was very boring.
9. This board game activity could improve my study habits.
10. This board game activity was very interesting.
11. I believe doing this board game activity could be beneficial for me.
12. I believe doing this board game activity could help me do better in school.
13. I would describe this board game activity as very comprehensive.
14. This board game activity was challenging to do.
15. I would be willing to do this board game activity again.

Part 2

1. What are the best features of the board game activity?

_____
_____.

2. What are the parts of the board game that need to be improved? How can it be improved?

_____
_____.

Appendix 3

TEST QUESTIONNAIRE

MULTIPLE CHOICE TEST

Directions: Read the questions carefully. Choose and encrice the letter of the best answer.

1. What is the terminal electron acceptor in the electron transport chain?
   A. ATP C. NAD
   B. Carbon dioxide D. Oxygen

2. In which organelle does aerobic respiration occur?
   A. Amyloplast C. Mitochondrion
   B. Chloroplast D. Nucleus

3. What is the net production of ATP from one glucose molecule through aerobic respiration?
   A. 2 C. 36
   B. 32 D. 38

4. What is the energy currency of all cells?
   A. ATP C. GTP
   B. $FADH_2$ D. NADH

5. The Krebs Cycle will generate
   A. 10 NADH & 4 $FADH_2$ C. 10 NADH & 2 $FADH_2$
   B. 8 NADH & 4 $FADH_2$ D. 8 NADH & 2 $FADH_2$

6. How many ATP molecules are produced for each glucose molecule used in fermentation?
   A. 2 C. 6
   B. 4 D. 10

7. Which of the following is formed during glycolysis?
   A. Citric Acid C. Glucose 6-phosphate
   B. Fumarate D. Oxaloacetate

8. In electron transport chain, how many ATP does a molecule of NADH produce?
   A. 3 C. 1
   B. 4 D. 5

9. What do you call the series of anaerobic chemical reactions in the cytoplasm that break down glucose into pyruvic acid forming a net profit of two ATP molecules?
   A. Calvin cycle C. Glycolysis
   B. Carbon-dioxide conversion stage D. Krebs cycle

10. What is the by-product of cellular respiration?
    A. ATP C. Oxygen
    B. Glucose D. Carbon dioxide

11. Where does the process of glycolysis start and end?
    A. Cytoplasm
    B. Mitochondrion
    C. Nucleus
    D. Plasma Membrane
12. What do you call the metabolic pathways that involve the breakdown of complex molecules to simpler compounds?
    A. Anabolism
    B. Catabolism
    C. Electron Transport Chain
    D. Krebs cycle
13. Which metabolic pathway is common to both fermentation and cellular respiration?
    A. Electron Transport Chain
    B. Glycolysis
    C. Krebs cycle
    D. Photosynthesis

14. What are the molecules being produced in glycolysis?
    A. Glucose, carbon-dioxide & water & pyruvate
    B. ATP, NADH & pyruvate
    C. ATP, glyceraldehyde-3-phosphate
    D. Pyruvate, glyceraldehyde-3-phosphate & water

15. The fermentation pathways produce no more ATP beyond the small yield from Glycolysis and the remaining reactions
    A. regenerate ATP
    B. regenerate NAD+
    C. dump electrons on an inorganic substance
    D. dump ions on an inorganic substance
16. What is the product of anaerobic respiration that may result to muscle fatigue by accumulation?
    A. Alcohol
    B. Ethanol
    C. Lactic Acid
    D. Pyruvate

17. ATP can be formed through substrate-level phosphorylation and this process requires
    A. an input of energy
    B. a high-energy phosphate group that is transferred directly to ADP
    C. a concentration gradient of protons
    D. the protein ATP synthase

18. The final output of the Krebs cycle include the following EXCEPT
    A. NAD^+
    B. $FADH_2$
    C. ATP
    D. CO_2

19. Which of the following is the key intermediate compound linking glycolysis to the Krebs cycle?
    A. ATP
    B. Acetyl CoA
    C. Malic Acid
    D. Pyruvic Acid

20. What happens during the process of oxidative phosphorylation?
    A. A high concentration of electrons is built up in the intermembrane space
    B. A high concentration of protons is built up in the mitochondrial matrix
    C. A high concentration of protons is built up in the intermembrane space
    D. A high concentration of electrons is built up in the mitochondrial matrix

Appendix 4

MECHANICS OF THE "ATP QUEST" BOARD GAME

1. This game will need **3-5 players.** This game can also be played by **3-5 pairs of players.**
2. Before the start of the game, there should be an assigned moderator for the game. It should not be one of the players of the game.
3. First, each player will select a token of his/her choice. All the players will place their tokens on the corner marked "GO".
4. Next, each player will take turns in throwing the dice. The player with the highest total starts the play *(Player 1)*, the next highest will be the second *(Player 2)*, and so on.
5. To start the game, Player 1 will roll the dice and move his/her token to the corresponding box. Player 1 will follow the instructions written on the box. After Player 1's turn, Player 2's turn will come next, and so on.
6. When a player lands in a ***Question Box***, he/she will have to pick one question under the category indicated in the box and **read the question and and his/her answer OUT LOUD.** If the player answered the question correctly, then he/she will get the corresponding ATP, NADH, $FADH_2$ and/or letter/s indicated in the *question card*. Otherwise, the player will not get any of the said rewards and the other players will have the opportunity to steal the question and get the said rewards.
7. The player who wants to steal the question needs to **BET 1 ATP**. If ever there are more than 1 player who want to steal the question, they need to roll the dice and the player with the highest total will be the first one to try to steal the question and if the first player was not able to answer the question correctly then the second player with the second highest total will have the chance to answer the question and so on.
8. **ONLY** questions from *"Vigorous Brain Exercise" and* for "*Extreme Brain Exercise" question box* can be stealed.
9. In answering the questions, the players will be given a maximum time of **5 seconds** for *"Little Brain Exercise" question box*, **15 seconds** for *"Vigorous Brain Exercise" question box*, **20 seconds** for "*Extreme Brain Exercise" question box* and for *"question chance card"* as well.
10. The letter/s got from the *question cards* can be collected by the player in order to form **NADH** and **$FADH_2$** which can then be exchanged for ATP when he/she lands on a landmark.
11. When a player lands in a landmark, which can be the ***Mitochondrion*** or ***Cytoplasm***, he/she can trade/exchange his/her *NADH* and/or *$FADH_2$* in the said landmark with the corresponding amount of ATP that they can be exchanged with.
12. When a player lands in ***Chance***, he/she will pick *one chance card* and follow the instruction written in the card.
13. For ***Question Chance Cards***, if the player was able to picked a ***Question Chance Card***, he/she will have the chance to receive rewards by answering the question correctly **BUT** the player will be asked to **GIVE UP 1 ATP** in order to access the *question chance card.* The questions will vary in terms of difficulty. The player can chose to decline the offer of the *questions chance card* and the other players will have the chance to steal the *question chance card* if the player will decline thhe offer or unable to answer the question correctly.
14. The players who want steal the question will be asked to **BET 1 ATP.** If ever there are more than 1 player who want to steal the question, they need to roll the dice and the player with the highest total will be the first one to try to steal the question and if the first player was not able to answer the question correctly then the second player with the second highest total will have the chance to answer the question and so on.
15. When a player lands in the ***Jail***, he/she will lose a turn and will have to give up one ATP.

16. As a player passes by **GO**, he/she will collect two (2) free ATP.
17. As a player lands in the ***Drop by in the park*** and in the ***Just Visiting*** as well**,** he/she will do nothing.
18. *The game will **END** if one player has collected **36 ATP**.*

Appendix 5

"ATP QUEST" SCORE BOARD

QUESTIONS	POINTS
Little Brain Exercise Questions	2 ATPs
Vigorous Brain Exercise Questions	3 ATPs and 1 NADH
Extreme Brain Exercise Questions	5 ATPs, 1 NADH and 1 FADH
Test your Luck Questions	5 ATPs, 1 NADH and 1 FADH

BOXES	POINTS	EQUIVALENT ATP POINTS
CYTOPLASM	1 NADH	2 ATPs
	1 FADH	0 ATP
MITOCHONDRION	1 NADH	3 ATPs
	1 FADH	2 ATPs

Appendix 6

"LITTLE BRAIN EXERCISE" QUESTIONS

1. What is the chemical formula for carbon dioxide?
2. How many carbons dioxide are produced by the Krebs cycle to each molecule of glucose?
3. Who discovered the Citric Acid Cycle?
4. What are the final outputs of the Krebs cycle?
5. How many molecules of NADH are produced in Krebs cycle per molecule of glucose?
6. What are the three main biochemical pathways of cellular respiration?
7. What are the by-products of cellular respiration?
8. What does the suffix "-lysis" mean?
9. What is the chemical formula for glucose?
10. What is the ultimate electron acceptor in aerobic respiration?
11. How many water molecules are produced in the cellular respiration to each molecule of glucose?
12. It is sometimes called the "powerhouse" of the cell.
13. What is the enzyme protein that synthesizes ATP?
14. What stages of the cellular respiration occur in the mitochondria?
15. Which of the process of cellular respiration does not require oxygen to function?
16. How many carbons are in glucose?
17. How many molecules of carbon dioxide would be produced by five turns of the Krebs cycle?
18. What is the net ATP yield from a molecule of glucose for eukaryotic cells?
19. In what cell structure does anaerobic cellular respiration take place?
20. What are the two types of fermentation?
21. What is the process of converting glucose into energy?
22. How many molecules of NADH are formed during glycolysis per molecule of glucose?
23. How many times does Krebs cycle turn with every glucose metabolized?
24. Where in the cell does the second stage of respiration take place?
25. What is the word used to describe the sum of all chemical reactions within an organism?
26. What energy molecule is produced by cellular respiration?
27. What is the starting molecule for glycolysis?
28. What is the substance that is produced during photosynthesis that is used for completion of cellular respiration?
29. What does FAD stand for?
30. Which type of fermentation occurs in yeast?
31. How many ATP are produced by the Krebs cycle to each molecule of glucose?
32. What stage of the cellular respiration occurs in the cytoplasm?
33. What is the end product of glycolysis?
34. What type of ATP synthesis occurs during glycolysis?
35. What does NAD stand for?
36. What does ATP stand for?
37. What is needed for aerobic respiration?
38. What is the jellylike material that makes up much of a cell inside the cell membrane?
39. What is the net production of ATP from one glucose molecule in glycolysis?
40. What is the other name for anaerobic respiration?
41. What is the molecule that acts as a short-term energy carrying molecule for the cell?
42. What cell organelle is specialized in aerobic respiration?
43. The starting materials in a chemical reaction are called _____.
44. Krebs cycle is also called _____.

45. In glycolysis, the activation of glucose is accomplished by _____.
46. The ending materials in a chemical reaction are called _____.
47. The capacity to make things happen or to do work is called _____.

Appendix 7

"VIGOROUS BRAIN EXERCISE" QUESTIONS

1. True or False: Pyruvic acid is oxidized when oxygen is present.
2. True or False: The first stage of cellular respiration occurs in the mitochondria.
3. True or False: Energy is released from foods when the bonds in food molecules are broken during cellular respiration.
4. True or False: Proteins yield the most energy when oxidized in the cellular respiration process.
5. True or False: As protons flow through the ATP synthase, energy is released to combine ADP and inorganic phosphate to form ATP.
6. True or False: Alcoholic fermentation explains why bread dough rises.
7. True or False: Right now, your cells are using mostly anaerobic respiration to make glucose.
8. True or False: Fats contain more energy than glucose.
9. True or False: The high concentration of protons in the inner mitochondrial space represents potential energy.
10. True or False: Cellular respiration creates energy for the plant cell.
11. True or False: Alcohol fermentation produces far more ATP than aerobic respiration.
12. True or False: Carbon dioxide is a necessary ingredient for cellular respiration.
13. True or False: Each step of the cellular respiration process is catalyzed by an enzyme.
14. True or False: Water is a product of cellular respiration.
15. True or False: During the oxidation of glucose, a net gain of ATP only occurs under aerobic conditions.
16. True or False: Plants undergo cellular respiration.
17. True or False: Proteins and fats can be sources of energy provided that they are modified so that they can enter the glucose metabolic pathways.
18. True or False: Some organisms can use both aerobic and anaerobic respiration.
19. True or False: Your body requires energy at all times, even when you are sleeping.
20. True or False: For every acetyl-CoA that enters the Kreb's cycle, the cycle turns twice.
21. True or False: The usefulness of fermentation as a means of deriving energy is limited because the end products are toxic to the producer.
22. Where in the mitochondria does the electron transport chain occur?
23. What type of fermentation occurs in muscle cells after strenuous exercise?
24. What is the final electron acceptor in lactic acid fermentation?
25. Which molecule enters the Kreb's Cycle?
26. What molecules transport electrons during cellular respiration?
27. During aerobic respiration, where is FADH2 produced?
28. Name one commercial product that undergoes alcoholic fermentation.
29. How many ATP molecules are used in the Kreb's cycle?
30. How many ATP molecules are produced in the electron transport chain with each molecule of NADH produced in the cytoplasm?
31. What kind of reaction converts NAD to NADH?
32. What is the beginning process common to both aerobic and anaerobic pathways?
33. During what stage of cellular respiration is the most ATP synthesized?
34. What is the reduced form of FAD?
35. Which stage of aerobic respiration requires CO2?
36. How many ATP molecules are produced in the electron transport chain with each molecule of NADH produced in the mitochondria?
37. During what process of aerobic respiration is NADH produced?
38. For each glucose, how many ATP, CO2, NADH, and FADH2 are produced? (note that NADH and FADH2 are not yet processed in the Electron Transport Chain)

39. How many ATP molecules are produced in the electron transport chain with each molecule of FADH2?
40. What substance is regenerated by fermentation?
41. What stage of cellular respiration oxidizes glucose to two molecules each of pyruvate, ATP, and NADH?
42. What is the oxidized form of NADH?
43. What is the energy-carrying compound that is involved in stage 1 and stage 2 of cellular respiration?
44. What do you call the overall process of utilizing a concentration gradient to produce ATP?
45. What is the beginning molecule for both lactic acid fermentation and alcoholic fermentation?
46. Which stage of aerobic respiration produces ATP and NADH and releases CO2?
47. Name one commercial product that undergoes lactic acid fermentation.
48. In aerobic respiration, which generates more ATP, substrate-level phosphorylation or chemiosmosis?
49. What metabolic process produces either lactic acid or alcohol?
50. When human muscle cells function anaerobically, they produce a waste product that differs from those produced when functioning aerobically. This waste product is called _____.

Appendix 8

"EXTREME BRAIN EXERCISE" QUESTIONS

1. What is the ultimate purpose of cellular respiration?
2. What is the process that happens during electron transport chain?
3. What process breaks down fat and why does the body break down the fat?
4. How is cellular respiration related to photosynthesis?
5. How does fermentation differ from respiration?
6. State the balanced chemical equation of the reaction during alcoholic fermentation?
7. True or False: Many scientists consider respiration to be the most important life process on Earth.
8. What is IUPAC name of pyruvic acid?
9. Combustion reactions and cellular respiration both produce energy. How are they different in terms of the energy they produce?
10. Under low oxygen conditions, the production of lactic acid in your body can lead to_____.
11. What are the proteins of the internal mitochondrial membrane that are specialized in electron transfer called?
12. Explain what happens to the pyruvic acid molecules made by glycolysis when it enters the mitochondria before starting the Krebs cycle.
13. True or False: 39% of the energy in glucose is converted to ATP, the rest is lost as heat.
14. What is the role of the electron transport chain in cellular respiration?
15. Where do carbon atoms in pyruvic acid end up following the Krebs cycle?
16. What ion moves across the membrane from the intermembrane space to the matrix that causes ATP synthase to spin and make ATP?
17. True or false: ATP synthase produces ATP when the H+ flow back into the matrix of the mitochondria.
18. What do you call a situation where there is no available oxygen in the cell stopping cellular respiration and ATP production causing cells to die?
19. Differentiate aerobic respiration from anaerobic respiration in terms of its process.
20. What stage of cellular respiration wherein two 3-carbon sugars are used?
21. True or false: ATP is the "energy currency" of the cell, so it makes sense that a molecule of ATP contains much more chemical energy than a molecule of glucose.
22. True or false: If oxygen is not present in the cell, the pyruvates cannot enter the mitochondria.
23. State the balanced chemical equation of the reaction during lactic acid fermentation.
24. State the balanced chemical equation of the reaction during cellular respiration.
25. What is the reaction in glycolysis that is involved in ATP consumption?
26. Why is aerobic respiration considered more efficient than anaerobic respiration?
27. True or false: Photosynthesis occurs in only some organisms whereas cellular respiration occurs in the cells of all living things.
28. True or false: Aerobic respiration evolved after oxygen was added to the Earth's atmosphere.
29. True or false: The poison cyanide can inhibit the last cytochrome of the electron transport chain, interrupting ATP formation causing the cell to die.
30. True or false: Lactic acid build-up changes the pH level in the muscles.
31. What compound is phosphorylated for ATP formation?
32. What is the purpose of building the concentration gradient of hydrogen ions in the mitochondria?
33. Why is NAD important in fermentation?
34. True or false: The consumption of oxygen has an inverse relationship with metabolic rate of aerobic cells.
35. What is the type of ATP synthesis that occurs during electron transport chain?

36. Under which conditions do cells use fermentation?
37. What role does molecular oxygen play in aerobic respiration?
38. Which among the process of cellular respiration uses NADH and FADH2 to produce ATP?
39. State the difference between aerobic and anaerobic respiration in terms of where it occurs.
40. True or false: Cells with a greater metabolic activity require more energy from ATP molecules than cells with lower metabolic activity.
41. True or false: When energized electrons released by hydrogen donors, NADH and FADH2, pass through a sequence of proteins, they gain energy each time.
42. State one difference between alcoholic fermentation and lactic acid fermentation.
43. What is the difference between aerobic and anaerobic organisms?

Appendix 9

"TEST YOUR LUCK" QUESTIONS

1. What is the intermediate molecule in alcoholic fermentation that is converted into ethanol?
   A. Pyruvic acid C. Glucose
   B. NADH D. ATP
2. Which of the following is the resulting compound when ATP releases energy?
   A. Heat C. ADP
   B. AMP D. Glucose
3. True or False: The first reaction of Krebs cycle produces citric acid.
4. True or False: Glucose is a carbohydrate that stores chemical energy in a concentrated and stable form.
5. True or False: In lactic acid fermentation, pyruvic acid is transformed into lactic acid.
6. Fill in the blank. Water is an end product in _____.
   A. Lactic acid formation C. Electron transport chain
   B. Fermentation D. Krebs cycle
7. How many ATP molecules are produced for each glucose molecule used in fermentation?
   A. 2 C. 6
   B. 4 D. 10
8. What substance causes the acidic flavor of fermented milk?
   A. Malic acid C. Oxaloacetic acid
   B. Lactic acid D. Citric acid
9. True or False: There is a release of CO_2 in alcoholic fermentation.
10. What is the energy-carrying compound that is only produced during the Krebs cycle?
11. True or False: ATP synthase pumps proton by passive transport.
12. Which of the following is considered a waste product of cellular respiration?
    A. ATP C. Glucose
    B. Oxygen D. Carbon dioxide
13. True or False: All life needs energy.
14. True or False: Fermentation causes cakes and breads to grow.
15. True or False: There is a release of CO_2 in lactic acid fermentation.

Appendix 10

TABLE OF SPECIFICATION ("LITTLE BRAIN EXERCISE" QUESTIONS)

Lesson Content	**Cognitive Domains**			
	Remembering	**Understanding**	**Higher Order Thinking Skills (HOTS)**	**Total**
Glycolysis	**Questions #'s** 1**,** 8, 9, 13, 16, 21, 22, 27, 32, 33, 34, 39, and 45			13
Krebs cycle	**Questions #'s** 2, 3, 4, 5, 10, 12, 14, 15, 17, 19, 20, 23, 24, 29, 30, 31, 35, 37, 38, 40, 42 , and 44.			22
Electron Transport Chain	**Question #** 18			1
Cellular Respiration	**Questions #'s,** 6, 7, 11, 25, 26, 28, 36, 41, 43, 46, and 47			11
Overall	**47**	**0**	**0**	**47**

Appendix 11

TABLE OF SPECIFICATION ("VIGOROUS BRAIN EXERCISE" QUESTIONS)

Lesson Content	**Cognitive Domains**			
	Remembering	**Understanding**	**Higher Order Thinking Skills (HOTS)**	**Total**
Glycolysis	**Questions #'s** 1, 6, 11, 15, 24, 27, 28, 32, 37, 40, 41, 45, 47 and 49.			14
Krebs cycle	**Questions #'s** 20, 25, 29, 31, 34, 35, 38, 42, and 46.			9
Electron Transport Chain	**Questions #'s** 5, 9, 22, 30, 33, 36, 39, and 44.			8
Cellular Respiration	**Questions #'s** 2, 3, 4, 7, 8, 10, 12, 13, 14, 16, 17, 18, 19, 21, 23, 26, 43, 48, and 50.			19
Overall	**50**	0	0	**50**

Appendix 12

TABLE OF SPECIFICATION ("EXTREME BRAIN EXERCISE" QUESTIONS)

Lesson Content	**Cognitive Domains**			
	Remembering	**Understanding**	**Higher Order Thinking Skills (HOTS)**	**Total**
Glycolysis	**Questions #'s** 8, 10, 20, 25, 26 and 38.	**Question #** 12		7
Krebs cycle	**Questions #'s** 6, 13, 15, and 23.	**Question #** 33		5
Electron Transport Chain	**Questions #'s** 2, 11, 14, 16, 17, 32, 35, and 41			8
Cellular Respiration	**Questions #'s** 1, 3, 4, 5, 7, 9, 18, 19, 21, 22, 24, 27, 28, 29, 30, 31, 34, 36, 37, 39, 40, 42, and 43.			23
Overall	**41**	**2**	**0**	**43**

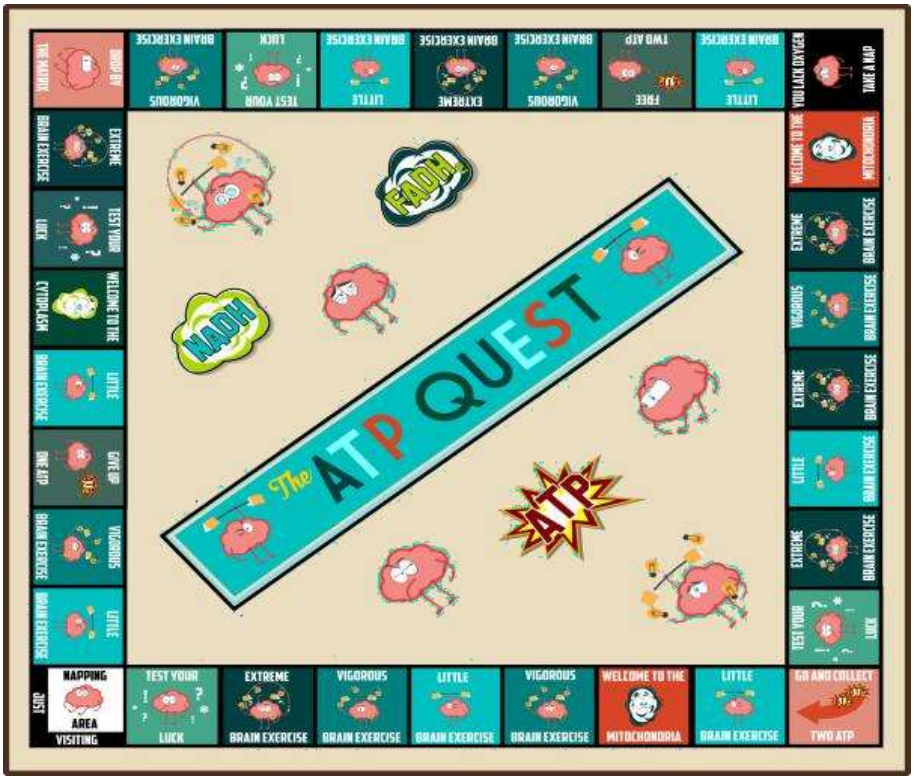
Appendix 13

TABLE OF SPECIFICATION ("TEST YOUR LUCK" QUESTIONS)

Lesson Content	**Cognitive Domains**			
	Remembering	**Understanding**	**Higher Order Thinking Skills (HOTS)**	**Total**
Glycolysis	**Questions #'s** 5, 7, 8, 9, 14 and 15.			6
Krebs cycle	**Questions #'s** 3 and 10.			2
Electron Transport Chain	**Question #** 11			1
Cellular Respiration	**Questions #'s** 1, 2, 4, 6, 12 and 13.			6
Overall	**15**	**0**	**0**	**15**

Appendix 14

ACTUAL DESIGN OF THE DEVELOPED BOARD GAME



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Dual Development of Board Game and Guided-Inquiry Activity in Teaching Electricity for Grade 5

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Abstract. The topic on circuits contained abundant misconceptions and there is a need to devise a teaching modality that will possibly address these misconceptions. The way of rectifying misconceptions should be n ways that engender high student engagement and facilitate accommodation of higher order learning and thinking skills. This research sought to develop a two-pronged modality to address both ICT-enabled classrooms and non-ICT enabled ones. A PhET-based laboratory activity and a board game named "Clash on Circuits" were developed and tried on two different public schools to see if an increment of performance can be observed. Eight (8) in-service teachers and four (4) pre-service teachers assessed the laboratory activity using an adapted analytic rubric, while the board game was tried out with selected students for applicability. In the development of the PhET-based laboratory activity and board game Clash on Circuits, the following were gathered: 1) The readability of the final draft of the PhET-based laboratory activity yielded an average of 78.43 Flesch Reading Ease score and 4.6 Flesch Kincaid grade level; (2) Evaluation of in-service to the developed PhEt-based laboratory activity rated the developed laboratory activity as 8.825 in the average which is exemplary and pre-service teachers rated the developed activity as 9.10 in the average which is also exemplary; (3) The readability of the Final Version of the designed board game has 76.2 Flesch Reading Ease score and 6.8 Flesch Kincaid grade level; (4) Evaluation of the in-service rated the developed board game as 3.75 in the average which is exemplary and preservice teachers rated the developed board game as 3.76 in the average which is exemplary; (5) The difference in the pretest and posttest was significant in S1 school implemented with designed board game, and there is no significant difference in the S2 school implemented with both PhET-based laboratory activity and designed board game; and (6) the respondents' perceptions from both schools S1 and S2 towards the developed laboratory activity and board game was 5.94 and 6.08 respectively, which was relatively too high and has very positive implication.

Keywords: Board game, Computer simulation, Laboratory activity, Circuits

INTRODUCTION

Expanse of the universe offers wide array of explorations. On earth, every human being strives to survive either by simple means or by scientific investigations. A formal investigation in science involves a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe, by which the educational sector conducts laboratory activities—distinctive and central focus in science curriculum. Early 1960's practical work in science education marked the students' engagement in various investigations, discoveries, inquiries and problem-solving activities hence laboratory became the center of science teaching and learning environment. Recently, the educational reform of spiral progression highlights the four (4) sciences to be taught at different quarters starting Grade 3 to Grade 10. Existing literatures support the abundance of misconceptions in different Physics topics and the need to address it at even earlier grades is an imperative. One such topic is on Direct Current Circuit. Experiences in teaching the subject electricity to prospective science teachers revealed that even after systematic and fairly advanced study in college, students were found to be incapable of qualitatively analyzing simple circuits. Gaining conceptual understanding in electricity seems to be very challenging and difficult for students in various school levels. Numbers of studies conducted worldwide indicate that students still have many difficulties and misunderstandings after systematics instruction (Fredette & Lochhead, 1980; Shaffer & McDermott, 1992; Duit & von Rhoneck, 1998). Most common difficulties were due to incomplete understanding of the abstract concepts, such as electric current and electric potential, and where Electricity had been a difficult concept for students because of its being an unseen component—an abstract topic where visualization is needed. Teachers need to help students understand what is happening in an electric circuit and explain its concept clearly. Analogy is also a powerful cognitive mechanism used to learn new abstractions, in the form of text, pictures, videos, and verbal perceptions, where unobservable relationship compromising the phenomenon may be depicted via computer simulations. Such computer simulations have special value as they offer high potentials for interactive learning in all domains of science education, but prior researches had demonstrated either effective or insufficient student learning-most often, when dealing with direct current circuits.

Therefore, practical laboratory activities to explore circuit connections, current, voltage and resistance need to be enhanced for maximum internationalization of the subject matter. Visual simulation would be employed as alternative learning environment by using simulation software called Circuit Construction Kit (CCK). However, 20th century education focused on rote memorization and acquired skills (reading, writing, calculation, history, science), and ability to think through and solve complex problems, or interact critically through language or media must be raised to a higher level of learning. One effective way to learn would be the employment of games to naturally support this form of education; this is according to the Institute of Play. So, game playing is an excellent way to help wire our brains in ways that are crucial to the what, why, and how of learning needs for the 21st century. It was in this premise that this research undertaking was conceptualized and developed with eight (8) in-service teachers and four (4) pre-service teachers to assess designed laboratory activity using a rubric. The in-service teachers were public school teachers handling Science subjects. The Pre-service teachers were 4th year physics students of Mindanao State University-Iligan Institute of Technology, 1st semester of A.Y. 2015-2016. This study was conducted at Doña Juana A. Lluch Memorial Central School and at North 1 Central School with one (1) class of Grade VI pupils per school. The respondents had performed the PhEt-based laboratory activity- with focus on developing a PhETbased laboratory activity and game board in teaching direct current circuits.

RESEARCH OBJECTIVES

This study, which aimed to develop a PhET-based laboratory activity and game board in teaching direct current circuits, sought to answer the following questions:

1. What was the readability of the designed PhET-based laboratory activity?
2. What was the general evaluation of the PhET-based laboratory activity by the pre-service and in-service teachers in terms of:
    a. Title
    b. Objectives
    c. Introduction
    d. Procedure
    e. Educational Value
3. What was the readability of the Mechanics of the developed board game *Clash on Circuits?*
4. What was the general evaluation of the board game Clash on Circuits by the pre-service teachers and student respondents in terms of:
    a. Content
    b. Creativity
    c. Rules and Instructions

METHODOLOGY

This part deals with methods and procedures used in this study. It includes the subject of the study, research design, methods and techniques, instruments in data gathering, and the statistical tools employed in the conduct of this research undertaking.

A. Laboratory Activity

• *Participants*

Eight (8) in-service teachers and four (4) pre-service teachers assessed the design laboratory activity using a rubric. The in-service teachers were all public-school teachers handling Science subjects. The Pre-service teachers were all 4TH physics students of Mindanao State University-Iligan Institute of Technology, 1st semester of A.Y. 2015-2016. This study was conducted at Doña Juana A. Llunch Memorial Central School and North 1 Central School with one (1) class of Grade VI pupils per school.
The respondents performed the PhET- based laboratory activity.

• *Research Design*

This study was qualitative with quantitative research that utilized the research and development design. Purposive sampling was used in selecting the in-service and pre-service teacher respondents and student respondents. Formative assessment through face validation was made by the thesis adviser and panel members.

• *Research Tools*

The Learning Competency of the laboratory activity was based on the K-12 Curriculum Guide. Readability was measured using the Flesch-Kincaid Readability Test to determine if the designed PhET-based laboratory activity was suitable for students of grade levels five and six. To measure the performance of the students, a pretest and posttest in the form of a multiple-choice test questionnaire was given. A rubric was used to assess the designed PhET-based laboratory activity and to determine the students' attitude towards the laboratory activity.

Stage 1: Development of Laboratory Activity

The development of the laboratory activity consisted of three stages, the first draft, second draft, and the final draft.

Designing Laboratory Activity

The topic was about electricity, more specifically about circuits. This was adapted from the K to 12 Basic Education Curriculum Guide in Science for Grade V. The objective of this study was taken from the learning competency found in the curriculum guide.

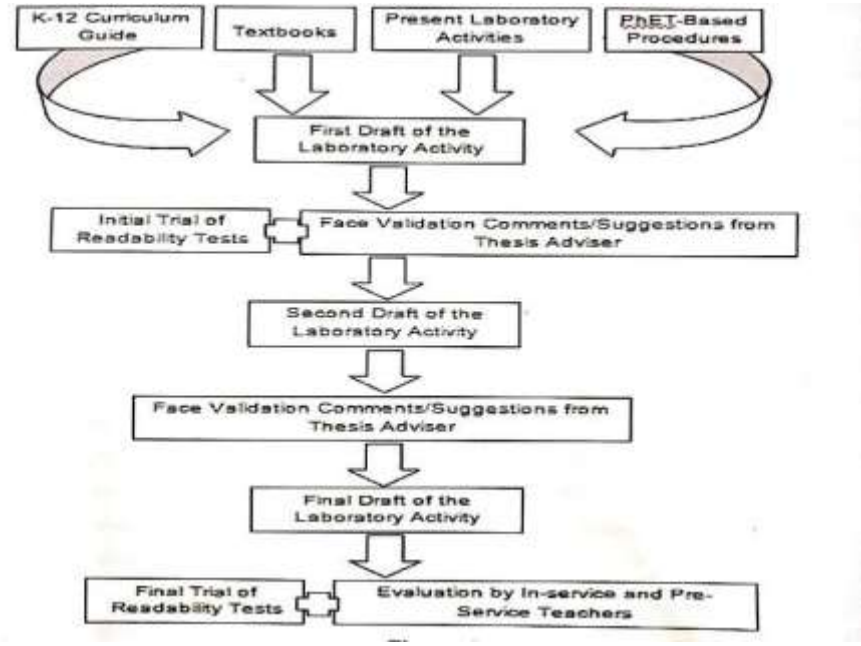

Figure 1 Conceptual Framework of Stage 1: Development of Laboratory Activity

The laboratory activity was developed based on PhET software, the Circuit Construction Kit (CCK). The procedures were designed with step-by-step process on how to manipulate the CCK. The students will have to construct a simple circuit using the CCK to light up a bulb. They investigated on changing the number or type of components, like battery or bulbs, if circuit could make a bulb brighter and dimmer. The mode working on the circuit was by dragging the circuit parts and putting it all together by simply connecting end to end, thereby reducing the usual inconvenience of actual objects. Thus, activity time was considerably reduced, since the assembly only needed to drag the pieces and connecting end to end.

Table 1 Mean Rating Descriptor for the Developed Laboratory Activity

Class Limits	Class Boundaries	Descriptor
1-2	1-2.5	No Evidence
3-4	2.6-4.5	Needs Improvement
5-6	4.6-6.5	Good
7-8	6.6-8.5	Satisfactory
9-10	8.6-10	Exemplary

B. Board Game

• *Participants*

The three (3) pre-service teacher respondents and all student respondents assessed the designed board game using a rubric. The pre-service teachers were all 4th year students of Mindanao State University- Iligan Institute of Technology, 1st semester of A.Y. 2015-2016. This study was conducted at Doña Juana A. Lluch Memorial Central School and at North 1 Central School with one (1) class of Grade VI pupils per school. The respondents performed the designed boardgame.

• Research Design

This study was a qualitative with quantitative research that utilized the research and development design. Purposive sampling was used in selecting the in-service and pre-service teacher respondents and student respondents. Formative assessment through face validation was made by the thesis adviser and panel members.

• *Research Tools*

The Learning Competency of the board game was based from the K to 12 Curriculum Guide. The readability was measured using the Flesch-Kincaid Readability Test to determine if the designed board game was suitable for students of grade levels five and six. To measure the performance of the students, a pretest and posttest in the form of a multiple-choice test questionnaire was given. A rubric was used to assess the designed board game and to determine the students' attitude towards the board game.

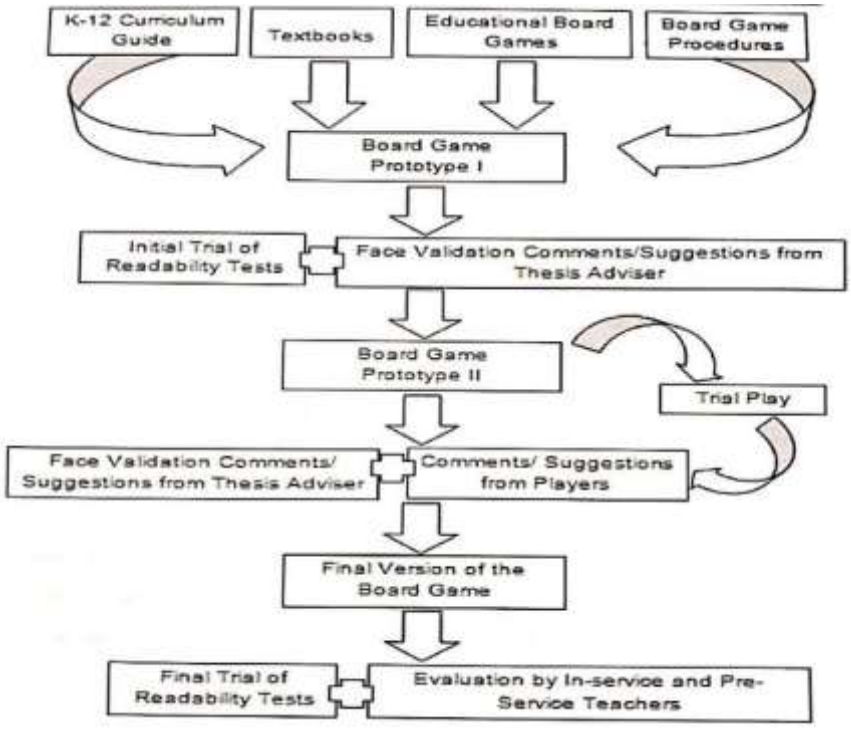

Figure 2 Conceptual Framework on Stage 1: Development of Board Game

Stage 1: Development of Board Game

The development of the board game composed of three stages, the Prototype 1, and Prototype II, and the final version of the Clash on Circuits board game. Each prototype consisted of one set of the board game, per set contains eight (8) elements: (1) Game board, (2) Tokens or player pieces, (3) Mechanics of the board game, (4) Dice, (5) Score sheet, (6) Question Cards, (7) Chance Cards, and (8) Circuit components.

Designing the Board Game

A prototype game board was designed based on the well-known board game Monopoly™, questions used in the game were taken from elementary textbooks, internet sources, and various test papers and quizzes. The questions were compiled, and were then categorized into four (4) following categories: Very Very Easy, Very Easy, Easy and Prominent Persons in Physics. Each category had its corresponding point/s if the question was answered correctly. The objective of the board game was to deliver a different learning environment where students could enjoy the static environment of circuits derived from the dynamic environment of PHET Simulation on Circuits.

The first draft's readability was tested using the Flesch Kincaid Readability Test. After the readability test, it was then face validated by the Thesis Adviser.

Table 2 Face Validation Comments and Suggestions on Prototype 1

Parts of the Board Game	Face Validation Comments/ Suggestions	Revision Done
Question Boxes	The questions were inorganized. They were placed below the question box.	The questions were placed in a separate box and organized per category.
Chance Boxes	The number of chance boxes were very limited.	Chance boxes were added in the game board.
Tokens	The tokens used were not child-friendly.	Cartoon characters with electric powers were printed to be used as tokens.

The revision of Prototype 1 was completed by incorporating suggestions from the evaluators as seen in Table 2 and improving the readability score of the mechanics of the board game, Prototype II was again checked and examined by the thesis adviser and the initial respondents who were BEED Science & Health senior college students. This resulted to another set of comments and suggestions which included the following: instead of using paper as the game board, the evaluators advised the researchers to layout the board game for tarpaulin printing; each question should have corresponding score, the number of components a player had should not be the basis in winning, the points in score sheets should be in place; and some trivia should be placed in the questions.

Table 3 Face Validation Comments and Suggestions on Prototype II

Parts of the Board Game	Face Validation Comments/Suggestions	Revision Done
Game Board	The paper game board was not durable.	The researchers lay out the game board and printed it in a tarpaulin, making it more durable.
Mechanics	The basis of winning, which was based on the number of components collected, was quite unfair. If a student collects a component	There are two ways that a player can win the game: (1) if the players has collected the

Parts of the Board Game	Face Validation Comments/Suggestions	Revision Done
	through a question card, he/she can lose it through jail or return component boxes.	required number of components;
	The font used in the questions are too bold, it should be changed to something more childfriendly.	(2) another basis of winning was through a score sheet, wherein each category of questions was given a corresponding number of points. The font was changed to a more child-friendly font, Comic Sans MS.

After incorporating the revisions on Prototype II, the final game board was produced. The final draft's readability was again tested using the Flesch Kincaid Readability Test.

Table 4 Mean Rating Descriptor for the Developed Board Game

Class Limits	Class Boundaries	Descriptor
1	1-1.5	Needs Improvement
2	1.6-2.5	Good
3	2.6-3.5	Satisfactory
4	3.6-4	Exemplary

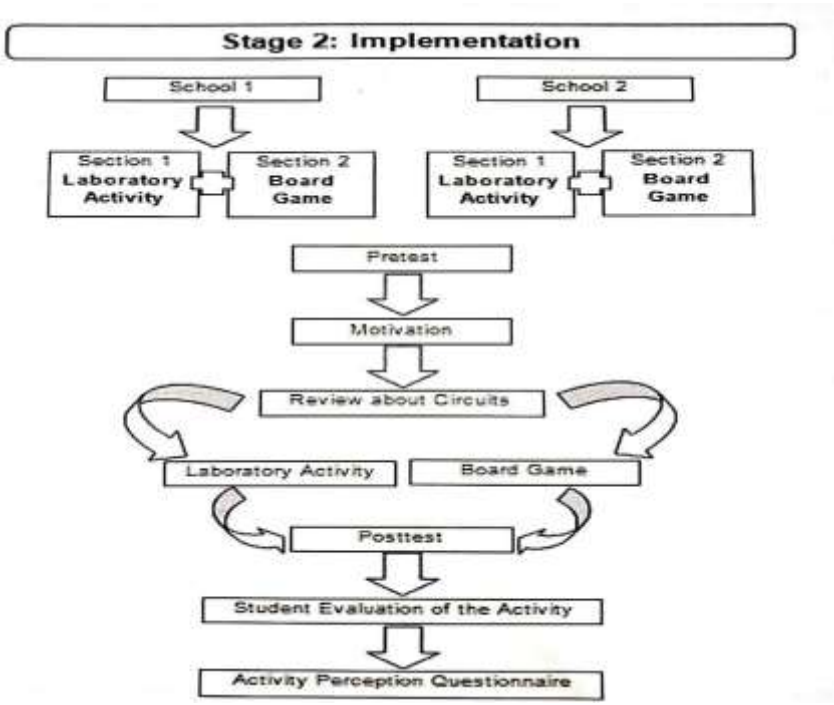

Figure 3 Conceptual Framework on Stage 2: Implementation

Stage 2: Implementation of the Laboratory Activity and Board Game in the Classroom

Two (2) classes from Doña Juana A. Lluch Memorial Central School and North 1 Central School were the student respondents of this study. The data gathering procedure was based on a Lesson Plan made by the researchers. First, a pretest was given to the class to determine the students' prior knowledge about the topic. Next, the class started with motivation about the topic through a game. Afterwards, a short review about circuits was conducted. The Power Point presentation used in the motivation and review could be seen in Appendix. Then, the designed activity, which was either the PhET-based laboratory activity or the board game, was facilitated. After that, the respondents were given posttest in order to measure the learning as a result of the course experience. Subsequently, analytic rubric was given to the respondents for them to evaluate the activity already done. Lastly, in order to measure the respondents' perceptions about the activity, they answered the activity perception questionnaire.

Table 5 Mean Rating Descriptor for the Activity Perception Questionnaire

Class Limits	Class Boundaries	Descriptor
1-2	1-2.5	Not all true
3-5	2.6-5.5	Somewhat True
6-7	5.6-7	Very True

DATA ANALYSIS

After the administration of the lesson, the researchers recorded and analysed the data that were gathered. The following were the statistical tools used in the data analysis of this study.

1. The **mean** was used to qualitatively measure the arithmetic average of the sets of data.

$$\overline{X} = \frac{\Sigma X}{n}$$

Where,

$\overline{X}$ = mean

ΣX = summation of the values and scores

n = number of respondents

2. The **standard deviation** was used to assess the student's performance in their pre-test and post-test.
3. The **T-Test** was used to determine if there was a significant difference in the students' performance in their pre-test and post-test scores.

RESULTS AND DISCUSSION

This part presents the analysis and interpretation and the data gathered by the researchers.

Development of the Laboratory Activity and Board Game

- *Readability of the Designed Laboratory Activity*

The readability of the laboratory activity was measured to make sure that the designed activity was suitable for Grade VI pupils. In measuring the readability of the designed laboratory activity, the Flesch Reading Ease and Flesch-Kincaid Grade Level were used.

The Flesch Reading Ease and Flesch-Kincaid Grade Level were readability tests designed to assess the suitability of reading passages for students at a particular grade level. These two tests have the same core of measures. However, they have different weighing factors.

First Draft

The first draft of the laboratory activity was tested for its readability. Afterwards, it was printed for face validation of the adviser and panel members. Some changes were suggested by the evaluators. Moreover, some graphics or illustrations were added to make the laboratory activity more relevant and interesting to the readers. Notes and word banks were placed were placed in order to provide students with explanation so that ideas will be expounded.

Final Draft

After incorporating the revisions on the second draft, the final laboratory activity was produced by the researchers. Afterwards, it was tested for its readability and evaluated by the pre-service and in-service teacher respondents.

Evaluation of Pre-Service and In-Service Teachers on the Developed Laboratory Activity

Table 6 In-service Teachers' Ratings on the Developed Laboratory Activity

CRITERION	MEAN RATING	DESCRIPTION
Title	8.125	Satisfactory
Objective	9.125	Exemplary
Introduction	8.75	Exemplary
Procedures	8.75	Exemplary
Educational Value	9.375	Exemplary
Overall	**8.825**	**Exemplary**

Table 6 presents the ratings of the In-Service teacher respondents on the developed laboratory activity. They rated the Title as Satisfactory while the rest of the categories were rated exemplary.

Table 7 Pre-service Teachers' Ratings on the Developed Laboratory Activity

CRITERION	MEAN RATING	DESCRIPTION
Title	8.75	Exemplary
Objective	8.75	Exemplary
Introduction	9.5	Exemplary

Procedures	9.25	Exemplary
Educational Value	9.25	Exemplary
Overall	**9.10**	**Exemplary**

Table 7 presents the ratings of the Pre-Service teacher respondents on the developed laboratory activity. They rated the rest of the categories as Exemplary.

The overall rating of the developed laboratory activity for the In-Service and Pre-service teacher respondents was Exemplary. This implies that the developed laboratory activity's title conveyed purpose or significance of the activity; the objective was conceptually correct, concise, specific and clear, and it used correct technical terminology and grammar; the Introduction was well-organized clearly presented and interesting, it integrated information from various sources, and provided a solid basis for doing the experiment; the Procedures included investigative elements that prove and stimulate conceptual understanding; and the Educational Value of the Laboratory activity was exemplary. The questions encouraged breadth and deeper understanding; the information provided selectively encourages thinking.

Teacher's Comments and Suggestions on the Developed Laboratory Activity

a. In-Service Teachers. Below are the comments and suggestions of some In-Service Teachers:

"Visually attractive, it must be emphasized whether the activity is individualized or group activity, the title of the activity must be clear not hanging." (IS_1)

"The activity is good but what if the net availability is limited?" (IS_2)

"Please consider my suggestion. Think about sir and ma'am." (IS_3)

"The laboratory activity is very interactive and interesting. These will spark the student's interest for the lesson." (IS_4)

b. Pre-Service Teachers. Below are the comments and suggestions of some Pre-Service Teachers:

"In using this type of learning tool, student's computer literacy should consider greatly." (PS_4)

Readability of the Mechanics for the Designed Board Game

The readability of the board game was measured to make sure that the designed activity would be suitable for VI pupils. In measuring the readability of the designed board game, the Flesch Reading Ease and Flesch-Kincaid Grade level were used.

Prototype I

The first draft of the mechanics for Prototype I was tested for its readability. Afterwards, it was printed for face validation of the adviser wherein some changes were suggested.

Final Version

After incorporating the revisions on Prototype II, the final game board was produced. Afterwards, the mechanics of the final version was tested for its readability and evaluated by the pre-service and in-service teacher respondents.

Evaluation of Pre-Service Teachers and Students Respondents on the Developed Board Game

Table 8 Pre-Service Teachers' Ratings on the Developed Board Game

CRITERION	MEAN RATING	DESCRIPTION

Content	4	Exemplary
Creativity	4	Exemplary
Rules and Instructions	3.33	Satisfactory
Cooperative Effort	3.67	Exemplary
Overall	**3.75**	**Exemplary**

The table 8 presents the ratings of the pre-service teacher respondents on the developed board game. They rated the rules and instructions as Satisfactory, and the rest of the categories as Exemplary. This maybe because words used in the rules and instructions of the board game were not appropriate for the respondents based on the Flesch Kincaid Grade Level.

Table 9 Students' Ratings on the Developed Board Game

CRITERION	MEAN RATING	DESCRIPTION
Content	3.77	Exemplary
Creativity	3.86	Exemplary
Rules and Instructions	3.77	Exemplary
Cooperative Effort	3.64	Exemplary
Overall	**3.76**	**Exemplary**

Table 9 presents the ratings of the student respondents on the developed Board Game. They rated all of the categories as Exemplary.

The over-all rating of the developed Board Game for the Pre-Service teachers and student respondents was Exemplary. It could be implied that the developed Board Game's Content presented high level of information and facts; high level of creativity was used to make the board game informative and appealing; the rules and instructions were-developed and easy- to-follow; and students contributed high level of cooperative effort in playing the Board Game.

Teachers' Comments and Suggestions on the Developed Board Game

a. Pre-Service Teachers. Below are the comments and suggestions of some Pre-Service Teachers:

"Very Creative." (PS_1)

b. Student Respondents. Below are the comments and suggestions of some Student Respondents:

"I want the monopoly game again. It is very fun that game but is lacking of time." (S_1)

"The lesson is all about the circuit. I learn that the components of the circuit are bulb,

copper wire, switch, dry cell. The activity was very fun and exciting especially when

the game started." (S_2)

"I think we should be given more time to play the game because it is full of knowledge

and very fun especially with the questionnaires." (S_3)

"I think this game enjoyable than Clash of Clans because Clash of Circuit is fun to know more about circuits for knowledge." (S_4)

"I think we should be given more time to play the game because it was very enjoyed and we learn many things about the different kinds of circuit." (S_5)

"In jail it a little bit an unfair I would like to add that if you in jail have no components shall have punishment or something to do after the game. It is my only

opinion po:).” (S_6)

Mean Test Scores of the Students in School 1 (S_1) and School 2 (S_2)

Table 10 Data Gathered for the Developed Laboratory Activity and Board Game

	School 1			
Descriptive Statistics	**PhET-Based Laboratory Activity**		**Clash on Circuits Board Game**	
	Pretest	Posttest	Pretest	Posttest
Count	36	36	44	44
Mean	7.75	9.53	11.18	12.64
Sample Variance	4.48	3.34	8.76	7.07
Sample Standard Deviation	2.12	1.83	2.96	2.66
Minimum	3	5	5	7
Maximum	12	12	17	18
Range	9	7	12	11

Table 10 presents the descriptive statistics of the developed Phet-Based laboratory activity and board game Clash on Circuits of the students from School 1 (S_1). The posttest mean was greater than the pretest mean. The scores in the posttest became more homogenous as the standard deviation deceased. This means the scores in the posttest became more clustered compared to pretest. Although the board game group has bigger score mean compared to PhET-based laboratory activity.

Table 11 Data Gathered for the Developed Laboratory Activity and Board Game

	School 2			
Descriptive Statistics	**PhET-Based Laboratory Activity**		**Clash on Circuits Board Game**	
	Pretest	Posttest	Pretest	Posttest
Count	33	33	33	33
Mean	8.67	9.70	10.85	11.39
Sample Variance	5.85	4.84	8.76	8.06
Sample Standard Deviation	2.42	2.20	2.96	2.84
Minimum	4	6	6	6
Maximum	13	14	18	18
Range	9	8	12	12

Table 11 presents the descriptive statistics of the developed PhET-Based laboratory activity and board game Clash on Circuits of the students from School 2 (S_2). The posttest mean was greater than the pretest mean. The scores in the posttest became more homogenous as the standard deviation decreased. The scores in the board game group were much higher than that of PhET group. There was parallelism in the result of schools S_1 and S_2.

What is common to both schools was that the scores in the posttest was bigger compared to pretest whether PhET of board game classroom. The scores in the posttest were more homogenous compared to the pretest. The posttest scores of board game classroom were higher compared to PhET classroom.

T-test Results of the Developed Laboratory Activity and Board Game in the School 1 (S_1)

Table 12 T-Test Results of the Developed Laboratory Activity and Board Game

School 1		
Hypothesis Test: Independent Groups (t-test, unequal variance)		
	PhET-Based Laboratory Activity	**Clash on Circuits Board Game**
Pretest mean	7.75	11.18
Posttest mean	9.53	12.64
Difference (Posttest-Pretest)	1.778	1.455
P-value (two-tailed)	**.0003**	**.0174**

Table 12 presents the T-test results of the developed PhET-Based laboratory activity and board game Clash on Circuits of the students from School 1 (S_1).

There was a significant difference between the pretest and posttest scores of the students of School 1 (S1) who performed the laboratory activity and board game, since p value was less than 0.05.

T-test Results of the Developed Laboratory Activity and Board Game in the School 2 (S_2)

Table 13 T-Test Results of the Developed Laboratory Activity and Board Game

School 2		
Hypothesis Test: Independent Groups (t-test, unequal variance)		
	PhET-Based Laboratory Activity	**Clash on Circuits Board Game**
Pretest mean	8.67	10.85
Posttest mean	9.70	11.39
Difference (Posttest-Pretest)	1.030	0.545
P-value (two-tailed)	**.0751**	**.4477**

Table 13 presents the T-test results of the developed laboratory activity of the students from School 2 (S_2).

There was no significant difference between the pretest and posttest scores of the students of School 2 (S_2) who performed the laboratory activity, since p value was greater than 0.05.

Students' General Perception Towards the Developed Laboratory Activity

Table 14 Students' Perception on the Developed Laboratory Activity

ACTIVITY PERCEPTION QUESTIONNAIRE		
Statement	**Mean Rating**	**Descriptor**
1. I believe that doing this activity could be of some value for me	6.61	VT
2. I believe I had some choice about doing this activity.	6.04	VT
3. While I was doing the activity, I was thinking about how much I enjoyed it.	6.21	VT
I believe that doing this activity is useful for improved concentration.	6.48	VT
5. This activity was fun to do.	6.29	VT
6. I think this activity is important for my improvement.	6.43	VT
7. I enjoyed doing this activity very much.	6.47	VT
8. I really did not have a choice in doing this activity.	2.69	NAAT
9. I did this activity because I wanted to.	5.67	ST
10. I think this is an important activity.	6.49	VT
11. I felt like I was enjoying the activity while I was doing it.	6.56	VT
12. I thought this was a very boring activity.	2.55	NAAT
13. It is possible that this activity could improve my studying habits.	5.66	ST
14. I felt like I had no choice but to do this activity.	2.90	NAAT
15. I thought this was a very interesting activity.	5.98	ST
16. I am willing to do this activity again because I think it is somewhat useful.	6.67	VT
17. I would describe this activity as very enjoyable.	6.63	VT
18. I felt like I had to do this activity.	6.56	VT
19. I believe doing this activity could be somewhat beneficial for me.	6.12	VT
20. I did this activity because I had to.	5.79	ST
21. I believe doing this activity could help me do better in school	6.51	VT
22. While doing this activity, I felt like I had choice.	5.86	ST
23. I would describe this activity as very fun.	6.84	VT
24. I felt like it was not my own choice to do this activity.	4.32	ST
25. I would be willing to do this activity again because it has some value for me.	6.97	VT
Overall Mean	5.94	ST

**Scores of these items are reversed*

Legend: 5.6-7 ***Very True***

2.6-5.5 ***Somewhat True***

1-2.5 ***Not At All True***

The students perceived that the activity was fun to do and very enjoyable. They believe that doing the activity is valuable. The students did the activity because they wanted to. They enjoyed the activity while doing it. The activity was not boring and could improve the students' study habits. The activity could help the students do better in school. The respondents' perception of the developed laboratory activity was 5.94 which was relatively too high and as very positive implication.

Students' General Perception towards the Developed Board Game

Table 15 Students' Perception on the Developed Board Game

ACTIVITY PERCEPTION QUESTIONNAIRE		
Statement	**Mean Rating**	**Descriptor**
1. I believe that doing this activity could be of some value for me	6.76	VT
2. I believe I had some choice about doing this activity.	5.56	ST
3. While I was doing the activity, I was thinking about how much I enjoyed it.	6.63	VT
4. I believe that doing this activity is useful for improved concentration.	6.70	VT
5. This activity was fun to do.	6.85	VT
6. I think this activity is important for my improvement.	6.77	VT
7. I enjoyed doing this activity very much.	6.68	VT
8. I really did not have a choice in doing this activity.	2.36	NAAT
9. I did this activity because I wanted to.	5.91	ST
10. I think this is an important activity.	6.44	VT
11. I felt like I was enjoying the activity while I was doing It.	6.72	VT
12. I thought this was a very boring activity.	2.55	NAAT
13. It is possible that this activity could improve my studying habits.	6.65	VT
14. I felt like I had no choice but to do this activity.	2.32	NAAT
15. I thought this was a very interesting activity.	5.59	ST
16. I am willing to do this activity again because I think it is somewhat useful.	6.64	VT
17. I would describe this activity as very enjoyable.	6.73	VT
18. I felt like I had to do this activity.	5.93	ST
19. I believe doing this activity could be somewhat beneficial for me.	6.67	VT
20. I did this activity because I had to.	6.67	VT
21. I believe doing this activity could help me do better in school.	4.65	ST
22. While doing this activity, I felt like I had choice.	6.64	VT
23. I would describe this activity as very fun.	5.69	ST
24. I felt like it was not my own choice to do this activity.	6.83	ST
25. I would be willing to do this activity again because it has some value for me.	2.76	NAAT
Overall Mean	**6.88**	**VT**

The students would be willing to do the activity again because they believe it is valuable. The activity was extremely fun for students. It was the students' own choice to do the activity. The students enjoyed the activity. The perception of the respondents towards the designed board game was 6.08 which was relatively too high and has very positive implication.

The students perceived both activities as exceptionally fun and enjoyable. Apart from the activities' entertainment significance, the students were willing to do the activity again because both were valuable. The respondents' perception towards both activities was comparatively too high and has an extremely positive implication.

CONCLUSION

In the review of forgoing findings, the researchers hereby arrive to the following conclusions:

1. The developed PhET-based laboratory activity is easy to read and very appropriate for Grade 5 students.
2. The developed board game "Clash on Circuits" is fairly easy to read and appropriate for Grade 7.
3. The grade level of the board game "Clash on Circuits" does not hinder the engagement and the enthusiasm, performance of the pupil respondents based on their perception to the activity as well as posttest result.
4. The PhET-based laboratory activity has the capacity to enhance cognitive understandings.
5. The designed board game "Clash on Circuits" has the capacity to enhance cognitive understandings.

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Appendix 1

A. Final Draft of the Laboratory Activity (Research Instrument)

Names: _____ Score: _____
School: _____ Group No.: _____

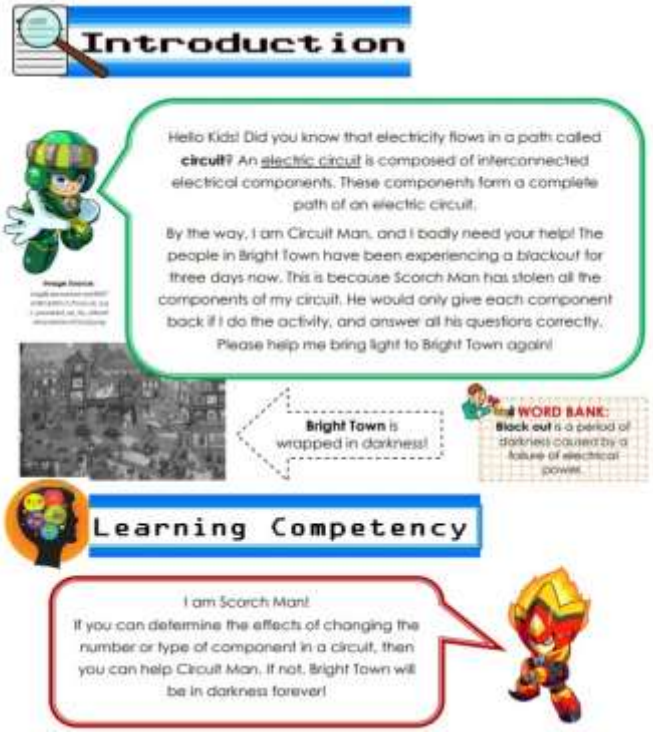
Mission Possible:
Make the Town Bright!

Directions:

1. Log on to your computer
2. Go to the following website: http://phet.colorado.edu/en/simulation/circuitconstruction-kit-dc
   Click the button that says "Play with sims…"
3. On the side bar under Simulations, select By Grade Level and pick Elementary School. Then, scroll down and click on the application that says Circuit Construction Kit (DC Only).
4. Click "Run now."

5. You now have the raw material to create a circuit. Take a moment to look over the site and find all the different materials. To build a circuit you will need several wires, a light bulb, a battery, a switch, and a resistor. Play with it to see how to grab and manipulate these tools.

6. Click the reset button.



Procedure

I. There are two types of circuits, the series circuit and parallel circuit. Using the Circuit Construction Kit, build a simple series circuit that consists of: 10 pieces of wire, 2 light bulbs, and 2 batteries.

Your circuit may look like the image below.

II. Now right click on one of the wires connected to a light bulb, and click remove.

Question A:
What did you observe?

Answer to Question A:

III. Return the wire you removed in II. Then, remove one of the wires touching the battery.

Question B:
What happened to the light bulbs and the blue dots in the circuit?

Answer to Question B:

IV. Return the wire you removed in III. Now, add a light bulb to the circuit.

Question C:
What happened to the brightness of the light bulbs? How about the flow of the blue dots in the circuit?

NOTE: To add a light bulb, right click on one of the wires connected to the bulb, then press **Split Junction**. Then grab a light bulb and wire to complete the circuit.

Answers to Question C:

V. Then, add two batteries to the circuit.

Question D:
What happened to the light bulbs? How about the flow of the blue dots in the circuit?

Answers to Question D:

VI. Raise your hand and let your teacher check your working series circuit.

Click the **Reset All** button to begin working on the next circuit. Parallel circuits provide more than one path for electrons to move. Create a parallel circuit in the Circuit Construction Kit, using 10 wires, 2 batteries and 2 light bulbs.

Your circuit may look like the image below.

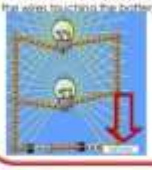
NOTE: Your circuit is complete and working when the light comes on and the blue dots begin moving.

VII. Now, right click on one of the wires connected to a light bulb. Remove the wire.

Question E:
What did you observe?

Answers to Question E:

VIII. Return the wire you removed in VII. Then, remove one of the wires touching the battery.

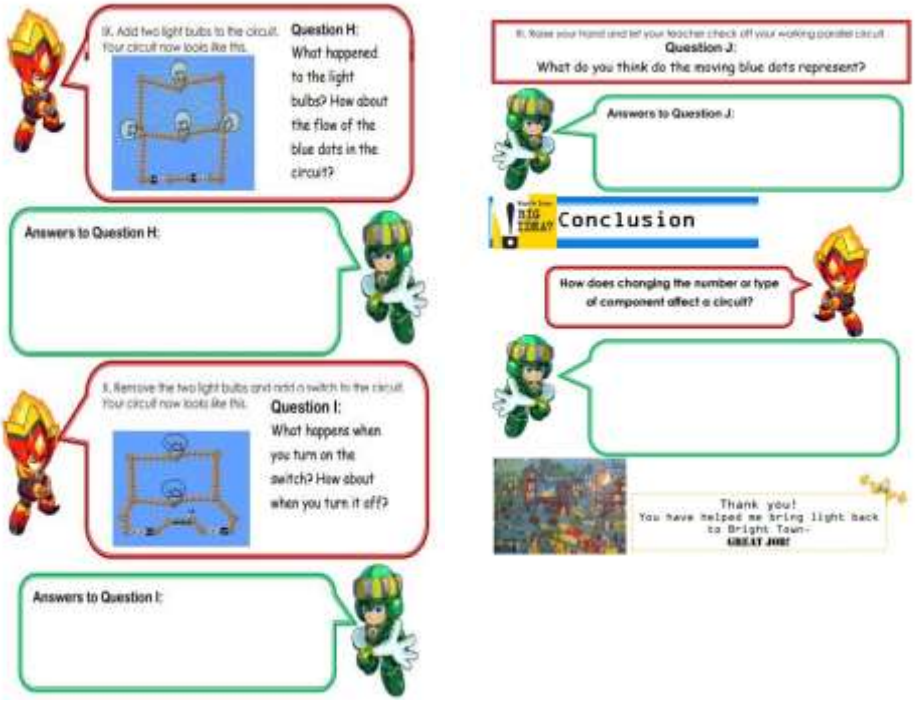


Question F:
What happened to the circuit?

Answers to Question F:

Question G:
What is the difference between removing the first wire and the second? Why is this significant?

Answers to Question G:



B. Final Version of Clash on Circuits Board Game (Research Instrument)

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Development of Comprehensive Project-Based Learning Packets in Teaching Conservation of Momentum

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Abstract. This study has developed a Project-Based Learning activity in the conservation of momentum using available online simulations. The teaching materials had undergone validation and revisions for further improvement before its implementation. This study pilot tested the Developed Project-Based Learning Activities in teaching Conservation of Momentum and determine the gain of students in terms of their achievement test results. Developed Project-Based Learning Activities for Grade Nine Science class as a form of instruction and assessment in an Online Distance Learning Modality. Sixty-one Grade Nine Students were chosen to answer the Pretest-Posttest Achievement test. Through a Qualitative with quantitative support research design with weighted mean, Dependent/Paired Sample T-test, the comparison of the student's achievement test scores through Normalized Gain, and their perception to the use of the developed learning material. Findings showed that the Developed Project-Based Learning Activities received a Very Good Rating from the evaluators. Based on their Achievement test results, students had a significant difference in their conceptual understanding and from their perception, it indicated that students' value and find relevance in learning the topic specifically road safety. Thus, the use of the Developed Project-Based Learning Activity in online instruction improved the students' conceptual understanding of Conservation of Momentum. It can also be seen that students who experienced PBL activity have a higher interest, motivation level and positive attitude towards momentum with a rating of 5.88 and a descriptive agreement the activities helped them learn the purpose of being careful about road and sports safety. With these findings, it is therefore concluded that self-directed, reflective and project-based learning strategies and teachers' instruction might be effective.

Keywords: Project-based learning, Momentum, Simulation, Develop

INTRODUCTION

One of the aims of education is to let the learners understand different phenomena in their environment and allow them to choose among natural options to aid their daily life challenges and develop life-long skills that will carry them throughout their existence.

This ultimate goal can be attained when abstract lessons in science are taught in a way that learners can build a correct conceptual understanding of the scientific ideas and find their application to real-world problems. According to Vosniadou (2019), students develop an understanding of science concepts based on three aspects of development: the creation of intuitive understandings, the process of science learning, and the presence of conceptual co-existence. To be effective in science education, it needs to make learners aware of their intuitive understandings, provide scientific information gradually and in agreement with students' learning progressions and develops their reasoning abilities and executive function skills. The stance stated above makes a construct that the more meaningful the learning experience by the learners, the greater the connections to students' understanding. Today, invaluable efforts are made by curriculum developers, administrators and teachers to uphold the Philippine standards of education, but still, the performance of the students in the country is low. Based on the 2018 Programme for International Student Assessment (PISA), Philippine students have low performance in science. This assessment tests critical thinking in math, science, and reading and do not measure memorization of facts, but rather demand that students draw on knowledge and real-world problem-solving skills. This result is also complemented by the low scores in the overall National 2 Achievement Test (NAT) (Albano Jr., 2020). These results show that Philippine Basic Education still has a gap in attaining the quality of basic education. Generally, with these results, we can say that student completers still lack in-depth nurturing of the essential skills. Thus, having a great impact on the lifelong learning of students to compete in the global world of work. This fact directly points out what students experience during their learning (in and out of the classroom) and the serious role of the educators in providing students genuine learning and eliminating the gap.

Many educators are implementing Project-Based Learning to address each learner's need. In many countries, it is currently considered to be an innovative approach to science and technology (S&T) teaching (Abdel et. al., 2016). PBL can reshape science education by engaging all learners in meaningful and robust knowledge-building experiences (Miller et. al., 2019). Learners are guided to construct educational experiences that prepare them to answer the challenges of real-world problems they will face after graduation (Taharu, et. al., 2019). In PBL courses, students complete various performance tasks that demonstrate that knowledge, understanding, and proficiency through tangible products or performances. Formative learning experiences, focused on the application of knowledge, occur throughout—problem-solving is the key to this type of knowledge acquisition. The format develops the students' ability to think critically, creatively, and productively about a problem, while also nurturing team skills. These meaningful experiences help students connect more deeply with the material while improving their enthusiasm and engagement with the work ("Project-Based Learning", n. d.). In the study of İlhan, 2014 entitled: "A study on the efficacy of project-based learning approach on Social Studies Education: Conceptual achievement and academic motivation", he found out PBL provides an effective way for teachers and students to develop creativity and supportive learning environment. This approach also has encouraged students' creative abilities (Isabekov and Sadyrova, 2018), learning motivations (Chiang and Lee, 2016) which are essential to extend their knowledge as they encounter unfamiliar 3 situations and to critically analyze scientific information to make informed decisions that affect their lives (Kim, 2005) (Rutledge, 2005). Many researchers have studied momentum through problem-based strategy (Sahin, 2010) and Activity-based (Ültay, E., & Alev, N., 2017) and none about learning Conservation of Momentum conducted in the Philippines in online and remote learning during a pandemic. This motivated the researcher to conduct this study to design a learning material that will provide students meaningful experience to think critically, creatively, and productively and to develop their learning. The researcher of this study developed a Learning material with activities that can be manipulated independently through online simulations which are advisable during pandemics to assist students' exploration and understanding of

science concepts. This study was therefore designed to make a PBL activity through an Inquiry-Based Approach to promote conceptual understanding of the conservation of momentum in Physics Grade 9. Moreover, this will be anchored on the constructivist theory where academic success will be based on the quality construction of the learner's conceptual understanding through the achievement scores and projects.

RESEARCH OBJECTIVES

The study aims to develop a Project-Based Learning activity in the conservation of momentum specifically to:

1. Develop the Project-Based Learning activity.
2. Determine the quality of the developed Project-Based Learning activity through:
   a. normalized gain between the pretest and posttest scores in the achievement test.
   b. quality of outputs from the Project-Based Learning Performance Task.
   c. perception of students on Project-Based Learning.
3. Investigate the gain scores in the achievement test.

METHODOLOGY

This study used pretest-posttest one group design online classroom-based study and quantitative with qualitative support research design. Qualitative findings could provide a mirror of the unseen characteristics of how a numerical value has arrived: underlying reasons, attitudes, and motivations behind various human behaviors. The quantitative data was based on the pretest and posttest achievement scores and quality of projects of respondents. Qualitative data is taken from the feedback of the evaluators and responses on the reflective journals of the respondents

Participants

The subjects of the study were 61 Grade 9 students officially enrolled in La Salle Academy during the school year 2020-2021. These students were enrolled on an online distance learning system. The Experts of the study were 14 experts in the field of Grade 9 and 10 Science, Science Coordinators and subject teachers rendering for 2 years and more in service who evaluated the Developed PBL and the achievement test.

Research Tools

The research instruments were used in the data collection of this study are as follows:

- K to 12 Basic Education Curriculum Guide

The Developed PBL Activities followed the Grade 9 MELCs of K to 12 Basic Education Curriculum Guide. The content, performance standards and competencies as the guide in the development of the learning materials.

- Developed Project-based Learning Activity

This material contained five (5) supplementary teaching materials on Conservation of Momentum developed based on learning competencies by the K to 12 Basic Education Curriculum Guide. These are: Activity 1- Defining Problem, Activity 2 - Define Momentum and Impulse, Activity 3 – Conservation of Momentum, Activity 4 – Problem Solving and Activity 5– Decision Day.

- Rubric for Evaluation of Supplementary Teaching Material

This rubric and scale were used by the evaluators to rate the content and appropriateness of the developed PBL Activity before the implementation. This is a Revised Version of the Rubric for Evaluating A Hands-on Activity from Hanifa M. Maurac.

- Perception Questionnaire

This questionnaire was adapted from Deci and Ryan (1994) cited by Variacion et. al (2021) in her thesis study entitled: Development of Differentiated Activities in Teaching Science: Its Effects on Students' Performance and was not modified by the researcher. This was used by the researcher to measure the perceptions of the respondents on the following areas: interest and enjoyment; application to real-life context; engagement, participation, self-regulation, value and relevance during the conduct of the PBL Activity. The items under interest and enjoyment determined respondents' interest, enjoyment and motivation as they meaningfully involved themselves in the activities. The items on value and relevance aligned with real-life contexts determined if respondents were able to connect and relate the learnings in real-life situations. In self-regulation items, respondents indicated whether they were engaging in their learning and was able to formulate and acquire knowledge and skills independently. This questionnaire summarized the effects of the developed PBL Activity in the respondents' learning process. This questionnaire had a Readability Index of 4.9 which means appropriate for Grades 8 to Grade 9 Students.

- Science Journal

Adapted from Capangpangan (2013) and used by Variacion et al. (2021), this questionnaire was used by the researcher to allow students to describe their experience and gather qualitatively their feeling and reactions to the developed PBL.

- Achievement Test

To determine the effects of the Developed Project Based Learning Activity on the respondents' conceptual understanding, the achievement test was administered. This achievement test is a researcher-made test that was validated by the research adviser and panel of experts. The achievement test consisted of thirty (30) items that composes of Conceptual Multiple choices. The achievement test underwent a validity test through item analysis. To test the consistency of respondents' answers and performance, the sequence of questions was repeated in the Post-test. The researcher-made achievement test was face and content validated by evaluators. Evaluators' comments and suggestions were used to see the significant difference in the respondents' performance. Table 1 below summarize the evaluators, comments and suggestions in the researcher-made Achievement test.

Table 1 Summary of Evaluators' Comments and Suggestions in the Researcher-made Achievement Test

Criteria	**Comments /Suggestions**
Visuals/ Graphics	Members agreed that items should be added with pictures/ visual representation
Question	Members agreed that some questions are knowledge-based, which should be changed to conceptual questions. Specific examples such as a football player or an athlete's view should be changed to a general example which is commonly observed

- Online Resources Used in The Study

This section contains the online simulations, Phet Simulations and other online references used in the development of Project-Based Learning Activities.

1. Professor Dave Explains Impulse and Momentum with Url youtube.com/watch?v=E13h1E_Pc00. The Professor Dave Video is open-source which learners and teachers can use to aid learning, as mentioned in the about section of the author's channel. He has a video lesson describing the effect of force in changing the momentum of an object.
2. Phet Simulation Ramp: Forces and Motion with Url https://phet.colorado.edu/sims/cheerpj/motion-series/latest/motion-series.html?simulation=ramp-forces-and-motion.

Figure 1 Phet Simulation Ramp

Build November 6, 2012, a simulation showing the concept of forces and motion of different objects such as crates, cabinets, 27 refrigerators, cats, and textbooks with friction and frictionless surface and with bouncy or brick walls.

PhET simulations are open source and free to all students and teachers. Thus, with this, teachers and students have free access to the simulations to aid learning, as mentioned in the About Section of the webpage, see picture below.

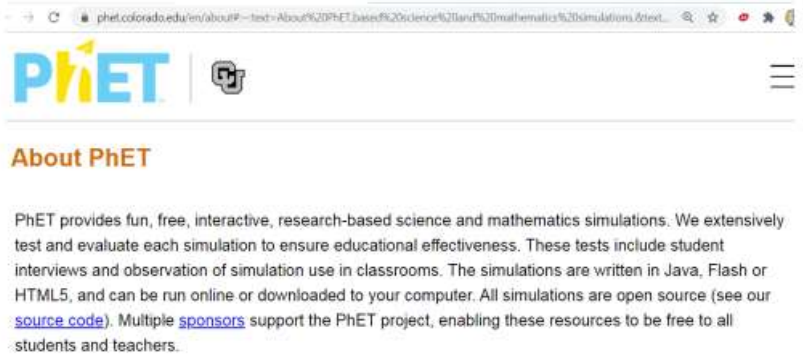

Figure 2 About Phet Webpage

3. Phet Simulation Collision Lab with URL https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html

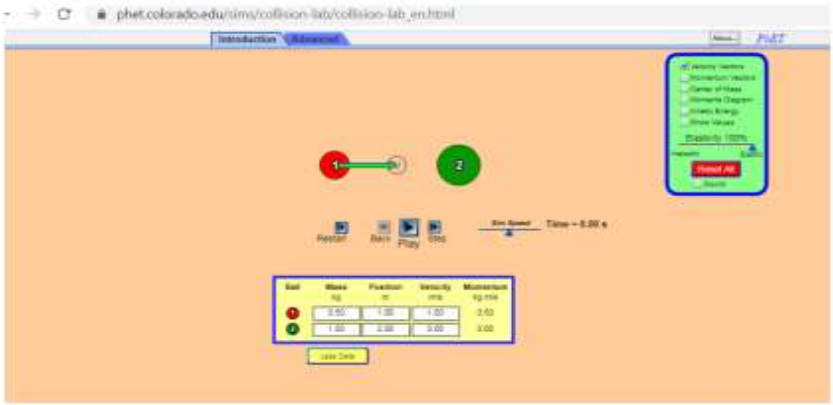

Figure 3 Phet Simulation Collision Lab

Build October 12, 2012, a simulation showing collisions in 1 and 2 dimensions of two objects with varying masses and elasticity. This is also showing the momenta and energy of the system during collisions.

4. Physics Classroom Egg Drop Simulation with URL https://www.physicsclassroom.com/Physics-Interactives/Momentum-and-Collisions/Egg-Drop/Egg-Drop-Interactive

The Egg Drop Interactive provides a virtual egg drop activity. Learners can vary the mass of the egg that is dropped, the height from which it is dropped, and the surface onto which it is dropped. The egg drop is simulated and the result is displayed in Figure 7. The impulsemomentum change theorem is used to show how the force is calculated from the egg drop parameters that are selected. The Interactive provides an eggcellent demonstration of how alterations in one variable affect another variable.

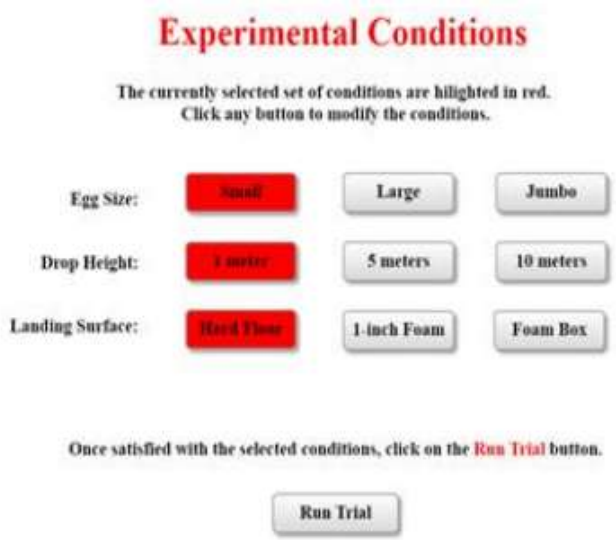

Figure 4 Physics Classroom Egg Drop Simulation

DATA COLLECTION

- Methods in the Development of the Developed Project-Based Learning Activities

First, the researcher determined the learning competencies of Conservation of Momentum in the DepEd K-12 Curriculum MELCs. Then the researcher developed activities based on the learning competencies. It was then validated by fourteen (14) Science in-service teachers who were teaching Science 9 and 10 for two years and more. The ratings, suggestions and comments of the evaluators were used in revising the supplementary teaching materials. After revision, the teaching materials were ready for try-out.

- Identifying Standards and Most Essential Learning Competencies

Developed Project Based Learning Activity was designed by the researcher based on the Most Essential Learning Competencies of the Department of Education K to 12 Curriculum Guide. In the development of the Developed PBL, the following steps were followed as seen in Figure 5.

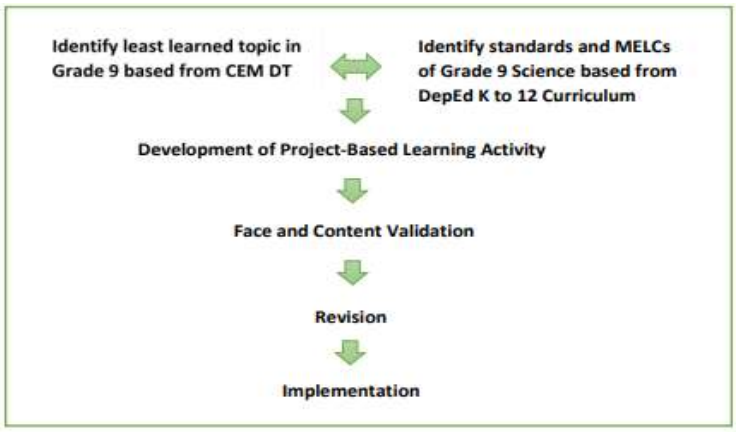

Figure 5 Development of the Developed PBL

DepEd K-12 Curriculum provided the list of standards and competencies for Grade 9 Science. Below is the identified standards and competencies for the fourth quarter.

Table 2 Standards and Competencies for Grade 9 Momentum

Quarter	**Content Standard** The learner demonstrates an understanding of…	**Performance Standard** The learner should be able to…	**Most Essential Learning Competencies**
4th	Projectile motion, impulse and momentum, and conservation of linea momentum	Propose ways to enhance sports relatec to projectile motion	Describe the horizontal and vertical motions of a projectile Investigate the relation-ship between the angle of release and the height and range of the projectile Relate impulse and momentum to the collision of objects (e.g vehicular collision) Infer that the total momentum before and after the collision is Equal

The researcher chose the topic MOMENTUM since this is one of the least learned topics of the grade level. The CEM DT Pre Test Result is shown below.

Table 3 CEM Pretest Diagnostic Test Result SY 2020-2021

Grade 9 Science Learning Competency	Proficiency Percentage	Proficiency Level
States conditions for a momentum change	46.8	Not Proficient

- Designing Developed Project-Based Learning Activity

The designing of the Project-Based Learning Activity is based on the Curriculum Guide of K to 12 Basic Education Curriculum Standards specifically Momentum. The five (5) activities included in the teaching material are researcher-revised and researcher-developed. The construction of pretest and posttest and other instruments used such as rubric for evaluator's validation and rubric for respondent's output and perception questionnaire as reflected in their science journals are also included in this step.

- Validation Process

A rating scale was used to validate the developed Project Based Learning Activity. Two elements were und in the validation process: Face Validation and Content Validation. The learning material contained five (5) supplementary teaching materials on Conservation of Momentum. These are: Activity 1- Defining Problem, Activity 2 - Define Momentum and Impulse, Activity 3 – Conservation of Momentum, Activity 4 – Problem Solving and Activity 5– Decision Day. The evaluators assessed the style and format for the face validity and the appropriateness for content validity. Each evaluator was given a letter (Appendix B) and a Rating Scale are used in the evaluation of the developed PBL. After which were collected back for interpretation. Their comments and suggestions were used for the revision.

- Revision of the Developed Project Based Learning Activity

The evaluator's suggestions and comments were significant in the revisions and modifications of the Developed Project Based Learning Activity before it was implemented. Specifically, the revisions focused on the areas of Curriculum Relevance, Presentation, Background/Information Objectives and Questions. All the evaluator's comments and suggestions were gathered. These criteria made the Developed Project Based Learning Activity valid, effective and ready for implementation.

- Try-Out

The try-out of the Achievement test and the Developed Project Based Learning Activity was administered to Grade 9 students who were officially enrolled or under the online distance learning system in La Salle Academy during the school year 2020-2021. A letter to the Principal was forwarded to seek approval of the pilot testing of the study. After the approval, the study was then pilot tested for 2 synchronous classes and 2 asynchronous classes with a 50-minutes duration per class. In the first synchronous class, a pretest assessment was given thru google form followed by a scenario/problem with the essential question and orientation for the developed PBL activity were given. In the next 2 synchronous classes, students completed the tasks and underwent the steps in PBL (Figure 2). The second synchronous was for feedback and critique to finalize their product/resolution to the essential question. Their final output was rated with the rubric (Appendix M). After the conduct of the posttest assessment, the respondents answered the Perception Questionnaire, Self-Reflection Questionnaire all in the google form. After the activity, students wrote their reflection (in google form) about their experience with the developed PBL. This activity has undergone approval from the Ethics Committee to ensure confidentiality of the identity and responses of the respondents who are below

eighteen years old. Figure 9 summarized the flow of the implementation of the developed PBL. Lastly, the scores and responses of the respondents were recorded and analyzed.

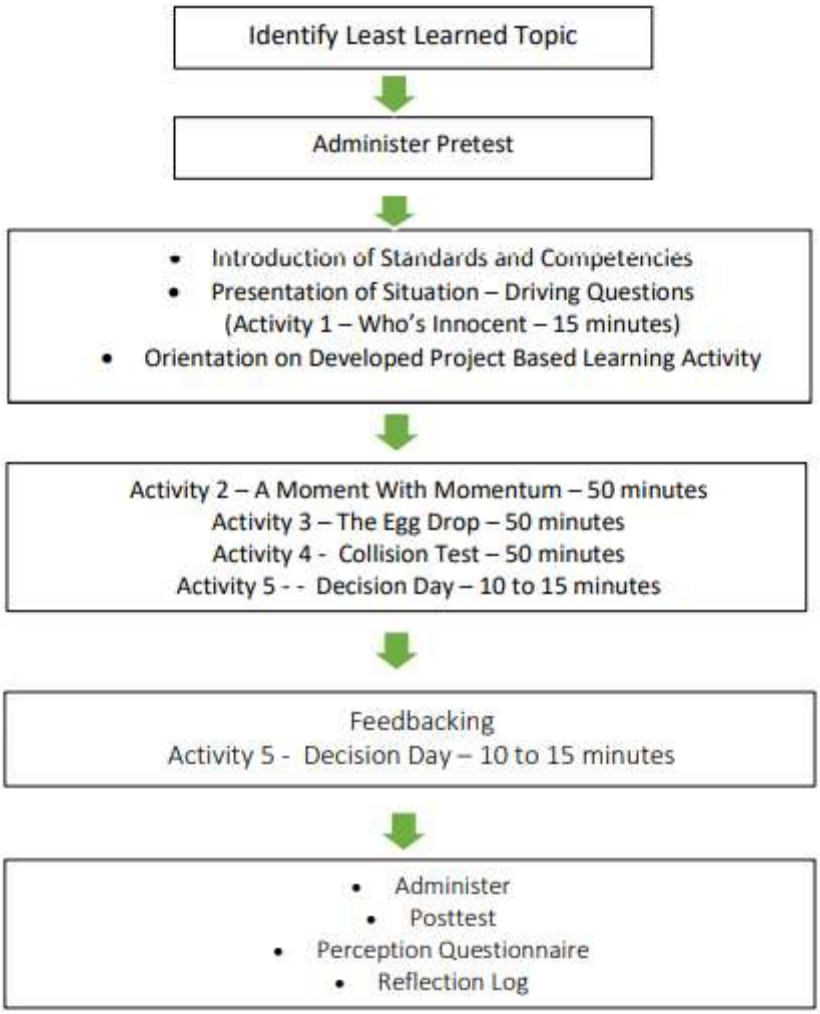

Figure 6 Flow of the Implementation of the Developed PBL

DATA ANALYSIS

Both quantitative and qualitative data were gathered to achieve the objectives of the study.

Rating Scale

A rubric with a rating scale was used by the experts to evaluate the developed PBL. The mean rating was used to analyze and interpret the quantitative data. To interpret the mean rating, the following intervals and descriptions were used (Adapted from Maurac, 2016) used by Variacion et. al (2021).

Table 4 Rating Scale

Rating	Equivalent:
4.20 – 5.00	Excellent
3.40 – 4.19	Very Good
2.60 - 3.39	Good
1.80 - 2.59	Fair
1.00 – 1.79	**Poor**

Statistical Treatment

The following treatments of data were used in the presentation of the results in this research study.

Dependent/Paired Sample T-test. This is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. This was used to compare the gain of the students in the pre-test and post test score.

Normalized Gain. It is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. This was used to compare the pretest and posttest scores.

Weighted Mean. The weighted mean is a type of mean that is calculated by multiplying the weight (or probability) associated with a particular event or outcome with its associated quantitative outcome and then summing all the products together. This was used to interpret the perception level of the students and the characteristics of the Developed PBL as rated by the experts.

Interpretation of the Respondents' Perception Questionnaire

To interpret the Respondents' Perception Questionnaire, the following ranges and scores and analyses were used (adapted from Deci and Ryan (2014) used by Variacion et. al (2021).

Table 5 Rating Scale for Perception Questionnaire

Scale	Range	Description	Analysis
1	1.00 – 1.84	Not at all true	Never true
2	1.85 – 2.70	Rarely true	Rarely true in less that 10% of the time
3	2.17 – 3.56	Occasionally true	Occasionally true, only 30% of the time
4	3.57 – 4.42	Somewhat true	Somewhat true, only 50% of the time
5	4.43 – 5.28	Frequently true	Frequently true, only 70% of the time
6	5.29 – 6.14	Usually true	Usually true, in about 90% of the time
7	6.15 – 7.00	Very true	All the time true

Level of Proficiency Adapted from Dep Ed (Llego, 2012)

To interpret the level of proficiency of the respondents in their pretest and post test results.

Table 6 Level of Proficiency

Level of Proficiency	Equivalent Numerical Value
Beginning	74% and below
Developing	75-79%
Approaching Proficiency	80-84%
Proficient	85-89%

Normalized Gain Interpretation

Adapted from Hake, 1999 and used Rani, Wiyatmo, & Kustanto, 2017 in his thesis entitled "Concept Attainment Worksheet to Enhance Concept Knowledge and Science Process Skills in Physics Instruction".

Table 7 Normalized Gain Interpretation

Standard Gain Score (g)	Criteria
$0.70 < (g)$	High
$0.30 \leq (g) \leq 0.70$	Medium
$(g) < 0.30$	Low

(Hake, 1999)

Coding of Data

The respondents and the experts were represented by codes:

A1 to A61: represent the Grade 9 students

E1 to E14: represent the In-Service Secondary Science Teachers teaching for two (2) years or more.

RESULTS AND DISCUSSION

This chapter presents the analyses and interpretation of the data gathered both quantitatively and qualitatively.

Development of the Project Based Learning Activity

The developed PBL was designed by the researcher with the assistance of the Thesis Adviser and 14 experts in the field of Grade 9 and 10 Science. It is all about Momentum (impulse and momentum and conservation of momentum). Prior to the development of the learning material, the researcher insured its alignment to the DepEd K-12 MELCs Identified Standards and Competencies which are targeting the power competencies essential for learners to learn in Grade 9 Science. Even during pandemic, under "Sulong EduKalidad," DepEd's battle cry moving forward, education must continue. From S. (2020), Salustiano Jimenez, DepEd 7 Director, stated:

... . 'That's what we're prioritizing now amid this crisis. We tried to find a solution that's suitable for these challenging times. It would be difficult for us to go all the way since we'll be using different modalities in the delivery of instructions and lessons."

Table 8 Alignment of Daily Learning Targets to DepEd K-12 MELCs Identified Standards and Competencies

Content Standard *The learners demonstrate understanding of...*	**Performance Standard** *The learners should be able to...*	**Most Essential Learning Competencies**	**Project Based Outcomes**
impulse and momentum, and conservation of linear momentum	propose ways to enhance sports related to projectile motion	Relate impulse and momentum to collision of objects (e.g., vehicular collision) Infer that the total momentum before and after collision is equal	Students were able to relate impulse and momentum in analyzing vehicular collision. Students were able to give a correct and detailed observation of the collision.

Designing Project Based Learning Activities

The learning material was designed in the alignment to K-12 Deped MELCs. This material contained five (5) supplementary teaching materials on Conservation of Momentum. These are: Activity 1- Defining Problem, Activity 2 - Define Momentum and Impulse, Activity 3 – Conservation of Momentum, Activity 4 – Problem Solving and Activity 5– Decision Day.

Based from the comments and suggestions of the evaluators, the PBL were revised before its pilot testing. Towards the last synchronous and asynchronous making of their performance task, validated questionnaire was administered to determine the normalized gain and students' perception to the learning material. The results from the data gathered were analyzed and treated with utmost confidentiality.

Evaluation of the Developed Project Based Learning Activities

The Developed Project Based Learning Activities were evaluated in two aspects; face and content validations which were done by the adviser of the researcher, administrators and in-service science teachers.

Table 9 Evaluators' Comments, Suggestions and Perception on the Developed Project Based Learning Activities

Area	**Summary of Comments and Suggestions**
Content	Members agreed that this is a good supplemental material to the distance and homebased learning, cater the different learning styles of the students and very useful in developing problem solving skills and logical reasoning.
Assessment	Include a rubric on how students will be assessed on this project
Activities	The members suggest to employ a personalized situation, application to the society or local community
Problem Solving	Problem Solving is difficult especially to slow learners since examples given need thorough analytical understanding for students to be able to come up with the correct answers.
Time Allotment	The members suggested to place a time allotment in each activity to give learners direction on when it should be accomplished.

Summarized in Table 9 are the comments and suggestions of the experts on the areas of Curriculum Relevance, Presentation, Background Information and Questions. Prior to the try out on Grade 9, other revisions were done based on the experts' suggestions.

Revisions of the Developed PBL Learning Activity were based from the comments and suggestions of the evaluators. Based from the accumulated comments and suggestions, instructional material is a good supplemental material to the distance and homebased learning, cater the different learning styles of the students and very useful in developing problem solving skills and logical reasoning. The experts have advised to revise the problem solving to contextualized questions for students to easily comprehend. Furthermore, the experts suggested to include rubric and time allotment to guide students on what to achieve for a specific period of time. With this suggestion and rating, it implies that the Developed PBL is a good material to guide students in their learning experience targeting the development of the 21st century skills even in online learning modality.

These comments and suggestions affirm to the idea of Levy (2008) cited by Willey (2016) that flexibility in content, process and assessment based on the students' strengths, needs and learning styles is the way for students to succeed. Learning experience should enhance life skills and increase students' motivations and engagement more in an online learning set-up.

Table 10 Mean Rating of the Developed PBL Learning Activity

Criteria	Rating	Description
CURRICULUM RELEVANCE	**4.23**	Very Good
PRESENTATION	**4**	Very Good
BACKGROUND/ INFORMATION	**3.6**	Very Good
OBJECTIVES		
QUESTIONS	**3.8**	Very Good
Overall Rating	**3.91**	**Very Good**

The table above presents the ratings given by the expert evaluators on the developed PBL learning activity based on the identified criteria. Based from the overall rating of 3.91 which is Very Good, it can be said that the experts agreed that the developed PBL learning was well crafted. The result of the rating connects to the Khaliq et. al (2015) that the interest and motivation of students depends on information and communication technology, specially the challenges and chances it provided in form of internet and other multimedia tools to beautify and the results of the projects their assembling and presentation. These factors were found in the activities.

Evaluators' Evaluation, Comments and Suggestions on the Researcher-made Achievement Test

Table 11 shows the evaluations, comments, and suggestions of evaluators in the achievement test. These comments are considered in the revisions of the researcher-made achievement test prior to pretest.

Table 11 Summary of Evaluators' Evaluation, Comments and Suggestions on the Researcher-made Achievement Test

Area	Comments /Suggestions
Visuals/ Graphics	Members agreed that items should be added with picture/ visual representation
Question	Members agreed that some questions are knowledge- based, which should be changed to conceptual question.
Instruction	Specific example such as a football player or an athlete's view should be change to a general example which is commonly observed even by nonathlete

Prior to test administration, three revisions were done based from the comments as some questions are ambiguous and knowledge-based. Thus, the achievement test was revised before the implementation.

Performance of Respondents in Pretest and Posttest

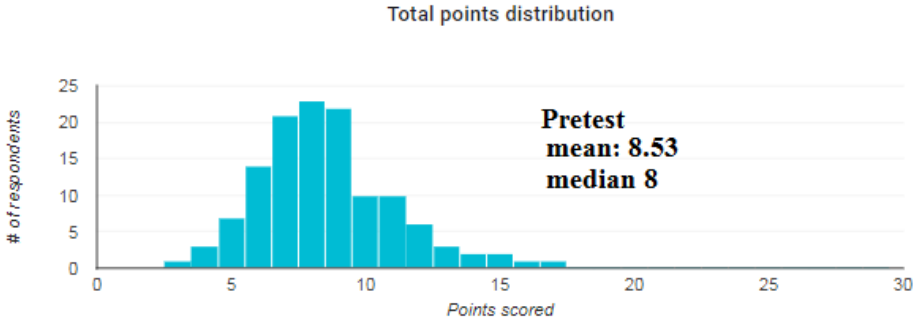

Figure 7 Performance of Respondents in Pretest

Figure 7 shows the point distribution of pretest scores of respondents. Its mean is 8.53 with a median score of 8. The respondents have the lowest score of 3 and the highest score of 17. Based on table 18, the class has a beginning proficiency level. This shows that majority of the respondents have a low average score which implies having limited idea about conservation of momentum.

Table 12 Level of Proficiency of Respondents' Pretest Performance

Average	Frequency	Percentage	Descriptor
75 – 79	1	1.64	Developing
74 and below	60	98.36	Beginning
Total	61	100	
Mean	8.53		Beginning

The result of the pretest imply that students have few knowledge or misconceptions about the topic which according to Efstratia (2014) needed to be enhanced through activities that connects problems with the real world. This gives the students an opportunity to develop additional skills, apart from cognitive skills, which are significant

abilities that could change our world to a better one, while they enhance their learning outcomes.

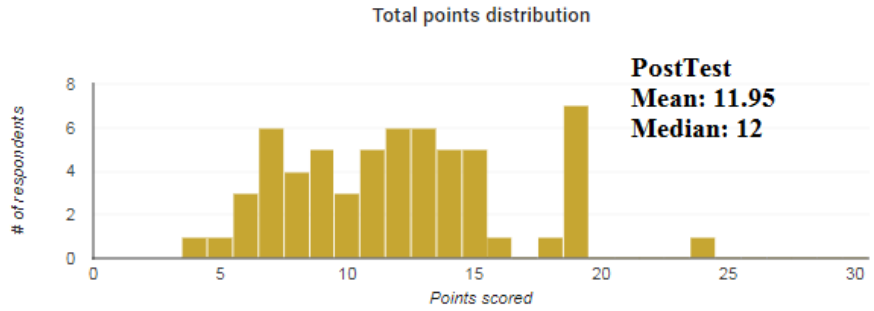

Figure 8 Performance of Respondents in Posttest

Figure 8 shows the point distribution of posttest scores of respondents. Its mean is 11.95 with a median score of 12. The respondents have the lowest score of 5 and the highest score of 24. Based on table 19, the class has an average beginning proficiency level. This means that there is a difference of the scores from pretest to posttest but remaining to the same proficiency level. This implication is probably an effect of the responses of the students in their reflection of having problems about cooperation among members of the group in performing the activities and also not getting used to online self-directed instructions shifted from a face-to-face classroom instruction.

Table 13 Level of Proficiency of Respondents' Posttest Performance

Average	Frequency	Percentage	Descriptor
85 – 89	1	1.64	Proficient
80 – 84	5	8.20	Approaching Proficiency
75 – 79	6	9.84	Developing
74 and below	49	80.33	Beginning
Total	61	100	
Mean	11.95		Beginning

Results shown in Table 12 and 13 mean the difference of scores of respondents from their pretest to posttest still remains to be in the same level of proficiency which is rated Beginning. This result, though found to be significant based from table 18, shows an evidence of the effect to the respondents during the transition stage from offline face to face to online distance learning. Based from the response to their Reflective Journal, a student said "*That some of the activity was hard and also I did not know what to do first and it's really hard to do the activity with my group mates since we cannot meet in real life."* This thought could have affected their learning since they were used to performing learning in a physical face to face set up and this shift caused academic stress to learners.

According to Mahapatra and Sharma (2020), academic-related stress (unable to avail online classes or submit their assignments, thus falling behind their peers in their

curriculum, problematic use of technology, increased gaming, spending more time on social media) has an adverse effect on academic performance, mental health and well-being of children and adolescents. Academic-related stress is significantly associated with reduced student academic motivation (Liu, 2015) and academic disengagement (Liu & Lu, 2011). This is also identified in the response of the student in their least like of the PBL saying *"Internet problems which is common for all of us since we use internet to access files, communicate with the group members".*

On the other hand, this learning opportunity also found light to developing independent learning as given by a student saying *"The time where I realized that even if we don't see each other, we make (things) learning happen no matter what".* This will allow the learners to appreciate learning independently and in an online modality which is needed to not hamper their intellectual growth even during pandemic.

Table 14 Comparison of the Pretest and Posttest Scores of Respondents

Achievement Test	Mean	Mean Difference	T-test	P-Value
Pre test	8.53	3.42	5.74434	**0.0000327**
Post Test	11.95			

*(α =0.05)

Table 14 shows the comparison between the Pretest and Posttest scores of the respondents. The mean score before the use of the developed PBL is 8.53 while after is 11.95. Comparing the mean scores before and after the administration of developed PBL shows that there is a mean difference of 3.42. A dependent/paired t-test observation was done to find out whether the mean difference is significant at α =0.05. It is indicated in Table 8 that the p-value is 0.0000327, which shows p-value < α.

Therefore, it shows that there was a significant increase in the conceptual understanding between scores of the respondents before and after the use of the developed PBL activity. The result supports the studies of Chiang and Lee (2016) and Ergül and Kargın (2014) which address on students engaging in their learning through PBL made better progress in motivation, problem solving, and on students' success. With this finding, it can be implied that teachers' instruction and activities effect students' learning if they are aware of their learning and learning at their own pace with or/and without a team.

Conceptual Understanding of the Respondents

Table 15 Average Normalized Gain of the Class

Achievement Test	Mean Average	Average Class Gain
Pre test	8.52	**0.241683**
Post Test	11.73	

Table 15 shows the 24% gain of the entire class on average. The gain starting at the pretest mean score of 8.52 and gaining to 11.73 in the posttest with a low rating (based from Normalized Gain Interpretation (Table 13)) but is still significant in the individual

gain of each respondents. This can be a good reference to determine the individual gain of each respondents.

Table 16 Average Learning Gain of the Class

Gain	Student Code	Number of Students	%
Positive	A3, A4, A5, A6, A8, A9, A12, A13, A14, A17, A20, A22,A26, A31,A32,A33,A35,A36,A37,A38, A39, A44, A46, A48, A49, A50, A51, A52, A58	45	**74%**
positive, below the class gain	A1, A27, A29, A30, A34, A47, A55, A54, A59	10	**16%**
Negative	A2, A7, A15, A16, A19, A21, A40, A43, A45	9	**15%**
zero	A7, A10, A18, A24, A28, A41,A53,A61	7	**11%**

Table 16 shows 74% of the class had a positive gain, from this population, 16% had a gain lower than the class gain which means these students had higher posttest scores from their pretest but the score is less than the average class gain. 15% had negative gains which means higher pretest than their posttest. These students probably had more misconception and confusion with the items. 11% had no gain from their pretest to posttest. These students had the same pretest scores and posttest scores. The students who had a negative and no gain probably did not cooperate in the conduct of the activities as this is one of the identified least like part of conduct of the activity as mentioned in the reflection journal of the respondents.

Table 17 Learning Gain of Respondents with Pretest Score Below Average Mean

Student Code	Pre	Post	Gain	Rating	Student Code	Pre	Post	Gain	Rating
A3	9	18	42.9	Medium	A33	5	12	28	Low
A4	9	14	23.8	Low	A35	7	13	26.09	Low
A5	5	14	36	Medium	A36	8	12	18.18	Low
A6	9	12	14.3	Low	A38	11	19	42.11	Medium
A8	11	24	68.4	Medium	A39	7	14	30.43	Medium
A9	9	19	47.6	Medium	A44	6	12	25	Low
A11	11	12	5.26	Low	A46	8	13	22.73	Low
A12	8	16	36.4	Medium	A48	3	15	44.44	Medium
A13	11	19	42.1	Medium	A49	7	13	26.09	Low
A14	7	13	26.1	Low	A50	6	19	54.17	Medium
A20	7	13	26.1	Low	A51	11	15	21.05	Low
A22	9	14	23.8	Low	A52	5	12	28	Low
A32	7	13	26.09	Low	A58	8	15	31.82	Low

Table 17 shows the individual gain of the respondents with pretest score below average mean. The highest individual gain starting at the pretest mean score of 11 and

gaining to 24 in the posttest with a medium gain rating. The lowest individual gain starting at the pretest mean of 11 and gaining to 12 in the posttest with a low gain rating. Based in the table, majority of the group have higher individualized learning gain of 63.14.

The results above support Bao (2006) stating that if individual gain is greater than class average gain, we can infer that students with low pre-test scores tend to have either smaller or similar score improvement than students with high pre-test scores. In this case, based from the respondents scores, students with low pretest scores have similar score improvement that the students with high pre-test scores. This implies that students with low pretest scores have gained more interest than those students with high pretest scores.

This result also is complementary to the result of the study of Han et. al. (2015) with the title "How Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) Affects High, Middle, and Low Achievers Differently: The Impact of Student Factors on Achievement" which showed low performing students had a statistically significantly higher growth rates on mathematics scores than high and middle performing students over the 3 years.

Table 18 Learning Gain of Respondents with Pretest Score Above Average Mean

Student Code	Pre	Post	Gain	Rating
A29	13	15	11.8	**Low**
A31	17	19	15.4	**Low**
A37	12	18	33.33	**Medium**

Table 18 shows the individual gain of the respondents with pretest score above average mean. The highest individual gain is 33.33, with a rating of medium gain, which is higher than the class average gain. The lowest individual gain is 11.8, which is rated as low gain.

Based in table 18, the range of individual gain of 21.53 which is lower than the average class gain. This idea is an example of an Idealized situation called Contraction Case of Bao (2006) on his study entitled 'Theoretical comparisons of average normalized gain calculations'. This case assumes that the students with above average pre-test scores have smaller score changes than the students with below average pre-test scores, but all students still remain on the same side of the distribution curves of the pre- and post- tests.

Using the normalized gain interpretation shown in table 13 of Chapter 3, it reveals that the performance of Grade 9 students on the conceptual achievement test in Conservation of Momentum under the online distance learning modality with the developed PBL used as learning material is low .

Moreover, the concept of an average normalized gain is a reasonable way to describe the learning of individuals with pretest scores below the average mean but a poor way to characterize the learning of individuals with a very low pretest score. One possible explanation for this split that bears investigating is whether there are certain key misconceptions that are not well addressed in the course. The presence of key misconceptions could result in the split observed if students who come in without these misconceptions are able to learn the remaining concepts at a standard rate dictated by the structure of the course (and thus achieve consistent gains), but students holding one or more key misconceptions are prevented from learning on a significant group of questions at the same rate as those who do not hold the misconception (and thus achieve reduced gains). Students achieving high pretest scores would be unlikely to harbor the key

misconceptions, while students achieving low pretest scores would likely hold one or more key misconceptions and therefore show varying levels of learning (depending on exactly how many were held or the impact of those that are held) (Pawl, 2015).

Perception of the Respondents

Table 19 shows a summary of the response to the Perception Survey of the Developed PBL Activity. Most respondents have agreed that the statements are Frequently True. With a Cronbach's α of 0.95 which rated the perception questionnaire to have an excellent consistency, this suggests that most of respondents perceive the activity favorably.

Table 19 Perception of the Respondents

Statement	Mean	Interpretation
I believe that doing the activities made me have more interest with the lesson.	5.09	Frequently true, only 70% of the time
I believe the activities are enabling us to relate to what is really true in real life situations.	5.83	Usually true, in about 90% of the time
I felt like the activities I did are helping me develop teamwork, communication and collaboration.	5.01	Frequently true, only 70% of the time
I enjoy doing the activity very much.	4.65	Frequently true, only 70% of the time
For me, the activities are important for my improvement because it encourages me to find more information and ask questions.	5.59	Usually true, in about 90% of the time
The activities are allowing us to develop and acquire good values and character.	5.46	Usually true, in about 90% of the time
I believe that the activities I did challenges me to succeed and do my very best.	5.65	Usually true, in about 90% of the time
I gained new self-regulated learning strategies and techniques through the activities I did such as taking down notes, sharing ideas with others and having further research.	5.21	Frequently true, only 70% of the time
I did the activities because I wanted and liked it much.	4.76	Usually true, in about 90% of the time
I think those activities motivate me to perform better because I believe it is not anymore about having good grades but experiencing lessons I could use in the future.	5.41	Usually true, in about 90% of the time
I believe the activities helped me learn the purpose of being careful and cautious about road and sports safety which me and my family are exposed to everyday.	5.89	Usually true, in about 90% of the time

Statement	Mean	Interpretation
I am willing to do the small and big group activities because it encourages me to be open-minded	4.97	Frequently true, only 70% of the time
I am very much interested in the activities because I got to learn ideas and concepts not only from my teacher but also from other sources like my classmates, from reading books and through browsing the internet.	5.23	Frequently true, only 70% of the time
While doing the activities, I felt like I developed the value of being mindful and careful of actions and decisions I make.	5.59	Usually true, in about 90% of the time
The online simulations, science terms and words were easy to understand since I have known them in real life.	5.03	Frequently true, only 70% of the time
I would describe the activity as very enjoyable because I can relate to the experiences shared by my classmates.	4.68	Usually true, in about 90% of the time
I would be willing to do the activity again because it has value for me.	4.67	Frequently true, only 70% of the time
18. Through big group activities, I realized that even if we have different ideas we can be successful if we try to develop teamwork	5.73	Usually true, in about 90% of the time
19. I would describe the activities as hard and difficult to do.	4.82	Frequently true, only 70% of the time
20. The activities are somehow easy because the examples used are common occurrences in road and sports events.	4.83	Usually true, in about 90% of the time

This data revealed that the students exposed to developed PBL has higher interest, motivation level and positive attitude towards momentum. This result affirmed the study of Bhagi (2017). According to Bhagi, a benefit of PBL is enabling student to face real world situations simulated in the form of projects which later may become their new hobbies, passions and careers which is relevant to the perception of the respondents. This simulation also improves student's level of creativity in applying new knowledge to respond to other situations. Furthermore, Guskey (2003), cited by Variacion et. al (2021) also states that teachers who develop useful activities, assessments, provide corrective instructions and give students chances to demonstrate success can improve their instruction and help students learn better. Therefore, the result shown above is another finding that strongly supports Project-Based Learning as an effective approach to make learners more interested, motivated, engaged in their learning.

Sample Best Product of Respondents

Shown in Figure 9 is a sample best product, a video presentation and the problem analysis and problem-solving strategy. The output was rated excellent based from the criteria: Understands the problem, Identifies Necessary Tools/ Formula, Develops a Problem-Solving Strategy and Implements a Strategy to Reach a Solution. The output indicates thorough understanding of the problem, correct identification of additional

information and tools needed to solve the problem, select and implement the problem-solving strategy to reach a valid solution.

The said product was done during their Asynchronous Science Class schedule. They were given freedom to choose their group members, by pair, triad or by four members. They had autonomy to solve the problem. The respondents were given the rubric upon the start of the task to assess their performance.

Figure 9 Product of Respondents

The said activity helped the respondents to apply their understanding and at the same time are reflective in making decisions while performing the tasks. This approach supports the idea of Khaliq et. al (2015) on students at the center of their learning process where they engage in long-term studies of the topics, connect their learning to the real world and collaborate with each other- by letting them solve a real-world challenge with their experience of the topic and have reflection.

Summary of the Reflection of the Respondents on the Use of Developed PBL Activities

As seen in table 20, the top three most learned lessons are Conservation of Momentum, Speed and Time and Road Safety. Respondents also enjoyed the PBL activity, Group Discussion and Online Simulations but least enjoyed the member's cooperation and the nature of independent learning since they were not used to the strategy. Moreover, respondents claimed that they were able to develop the values of Teamwork**,** Communication and Critical-Thinking. Lastly, respondents suggested that they want to experience more flexible grouping, easier task, longer time for the tasks and more interactive online simulation activities.

Table 20 Summary of Perception of Respondents' Responses of Developed PBL

Responses	F	%	Rank
Most Important Things Learned			
1. Conservation of Momentum	14	23	**2**
2. Speed and time	3	5	**3**
3. Road Safety	38	62	**1**
Values and Skills Developed			
1. Teamwork	25	41	**1**
2. Communication	13	21	**2**
3. Critical-Thinking	5	8	**3**
Most Enjoyable and Meaningful Experience			
1. Group Discussion	17	28	**1**
2. Online Simulation Activities	9	14	**3**
3. PBL	10	16	**2**
Least Enjoyable and Meaningful Experience			
1. Member's Cooperation	23	38	**1**
2. Nature of experiential, independent learning	27	44	**2**
Suggestions for the Improvement of the Activity			
1. Flexible Grouping	14	23	**1**
2. Easier task	12	20	**2**
3. Longer time for the tasks	9	15	**3**
4. More interactive online simulation activities	4	7	**4**

With these results, it supports the idea of Chen (2019) cited by Gerhátová (2020) that the idea of teaching Physics is not to pass on a certain amount of knowledge to students but to prepare them for planned work, independent knowledge acquisition and problem solving. It has been evident that students were able to have undergone a self-regulated learning process, having autonomy with the design, and coming up with a solution and a reflective learning in developing the conceptual understanding. Though some of the students had expressed experiencing behavior such as less cooperation and less participation, majority had also developed the skill and attitude to manage such problem which we have seen occurring mostly in the real world. Therefore, based from the result above, the developed PBL is found to be a good way for respondents to develop life skills in preparation for bigger tasks and problems in the real world.

CONCLUSION AND IMPLICATIONS

Based on the findings and analyses, the researcher concluded that the Developed Project-Based Learning Activity significantly brings positive effects to students' conceptual understanding. This is supported by the pieces of evidence drawn from the findings, namely:

1. The developed PBL Activity were aligned to the K to 12 Basic Education Standards and Most Essential Learning Competencies.
2. Based on the result of the evaluation of the developed PBL, the activities were rated based on the different criteria as Very Good and were ready to be implemented.
3. After the pilot testing of the developed PBL, results showed a significant difference between the Pretest and Posttest results of the students. Thus, the use of the

Developed Project-Based Learning Activity in online instruction improved the students' conceptual understanding of Conservation of Momentum.

4. It can also be seen that students who experienced PBL activity have a higher interest, motivation level and positive attitude towards momentum based on the checklist and a descriptive agreement that the activities helped them learn the purpose of being careful about road and sports safety.

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Development of Card Game Flip It in Learning One Dimension Kinematics

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Abstract. This study is an attempt to develop a supplementary material in teaching one-dimensional kinematics through card game. The study has dual purpose of lesson supplementation and as repeatable activity for review and as alternative material for class interruptions. Provisions were assured that the contents of the curriculum were targeted in the design of the game. It was evaluated 4.81 or very good in goals and objectives; 4.83 or very good in card design; 4.7 or very good in components and organization; 4.87 or very good in playability or playfulness; and 4.77 for usefulness with an overall average of 4.8. The mean normalized gain of the sample respondents is 0.46 or medium gain. The evaluation of experts and the normalized gain of the respondents point to the viability of the card game as promising intervention material in learning one-dimension kinematics. The use of the card game can be as instructional support, as supplementary material, as review material, and as pre-lesson activity. The study concludes that learning science can be engendered in a non-sequential form like what happened in this study.

Keywords: One-dimensional kinematics, material, game

INTRODUCTION

In many countries, the role and function of schools are changing, and so are the expectations of teachers. Teachers are being asked to teach in increasingly multicultural classrooms, to place a greater emphasis on integrating students with special learning needs, to make more effective use of information and communication technologies for teaching, to engage in more planning within evaluative and accountability frameworks, and to do better to make the learning environment as effective as possible

Physics is perceived to be a challenging subject. Physics, according to Oladejo et al., (2011), is one of the science subjects that students find difficult in school but Sheriff et al., (2011) said that physics is regarded as the most fundamental science subject, whose concepts and techniques help in the advancement of all other branches of science [2]. That's why physics is important because it contributes significantly to many of the inventions that shape modern life and has helped to explain many of the events that occur in everyday life. Physics is critical to the modern world's technological breakthrough. According to Erinosho (2013), physics is fundamental to comprehending the complexities of modern technology and is required for a nation's technological advancement [3]. Physics holds a delicate position in physical science (Shamim, Rashid, and Rashid 2014), which is why its teaching and learning must be taken seriously but doesn't have to be boring.

Incorporating games into education is frequently more effective than traditional teaching methods in increasing students' learning motivation, active participation, and concentration. Furthermore, Kirikkaya et al., (2010), said that games can improve students' social skills as well as their understanding and problem-solving abilities [4]. The search for creative ways to enhance the teaching and learning of science subjects, combined with the growing popularity of games, has led to increased study of Game-Based Learning (GBL) in the classroom. The use of games in the classroom has steadily increased as researchers and educators alike become more convinced of their high potential to facilitate the learning of science subjects (Morris et al., 2013) and promote positive changes in the school curriculum (Barton et al., 2018; Smith & Munro, 2009). Accorrding to Berland and Lee (2012) this methodology has also been shown to promote social development [5].

A game is a type of play in which participants must adhere to certain rules. (Houghton et al., 2013) defines educational games as the use of games to support in teaching and learning. Games can be used as a support tool to complement traditional teaching methods to improve the learning experience of the learners while also teaching other skills such as following rules, adaptation, problem solving, interaction, critical thinking skills, creativity, teamwork, and good sportsmanship. Learning should not be boring, and it should not be limited to rote memorization, in which students learn and grasp concepts through repetition or cramming. Teachers can use the energy and innovative thinking that technology in learning provides to improve student performance [6].

This study aims to provide a new strategy in learning physics subjects by making students actively involved in the classroom. Specifically, this study aims to enhance students' engagement in learning physics for better understanding and learning process in the class through a developed card game that focuses on One Dimensional Kinematics for Grade 12 STEM students.

RESEARCH OBJECTIVES

Physics has been challenging the students, and we can all agree that it is a difficult subject to pass. Most especially when there is no interesting and motivating factor to hype up the students to learn. Teachers are still sticking to the standard way of teaching. That being the case, the purpose of this research is to create a Card Game to enhance students' engagement in learning one dimension kinematics and to test its usefulness in the classroom.

The Development of Card Game Flip it in Teaching One Dimension Kinematics aims to:

1. Develop a Card game on One Dimension Kinematics
2. Evaluation of card game
   a. by the experts
   b. by the learners

3. Make trial Implementation
4. Investigate the performance of the learners
   a. difference in pretest and post test
   b. the normalized gain of the learners
5. Determine the perception of the students to the developed card game

NULL HYPOTHESIS

H_0 : there is no significant difference in pretest and post test scores

METHODOLOGY

This study uses quantitative and descriptive type of research. Quantitative and descriptive method would be used to evaluate the numerical results of the given assessment. This includes the rating of the science teachers towards the developed card game, the scores of the students during the pretest and posttest, the students rating in the evaluation, and the rating of the students towards the developed card game. And the perception of the students towards the card game. The science teachers evaluated the developed card game to determine its strengths and weaknesses.

Convenience Sampling was used in selecting the respondents of the study due to the availability of the respondents. The Learning Competency of the educational card game was based on the K to 12 Science Curriculum Guide.

Participants

Participants of the study is limited only to Grade 12 students in Iligan City, currently taking General Physics subjects this school year 2021-2022 and teachers from private and public school who are teaching General Physics subject in Iligan City. But because of the pandemic, limited face to class and modular distancing, it's hard for us to have grade 12 respondents, and the only available students that we could find are grade 10 students.

Research Tools

Researcher-Made Card Game - This will be used in implementation and game play setting.

Rating Scale - A 5-scale rating scale was adopted from the study of Gutierrez which is also about an educational card game. The rating scale has five categories: goals and objectives, card design, components and organization, playability and playfulness, and usefulness.

Achievement Test – A 20 item questionnaire for the pretest and posttest. The topic will be focused on One Dimension Kinematics. The questionnaire is a multiple-choice questionnaire.

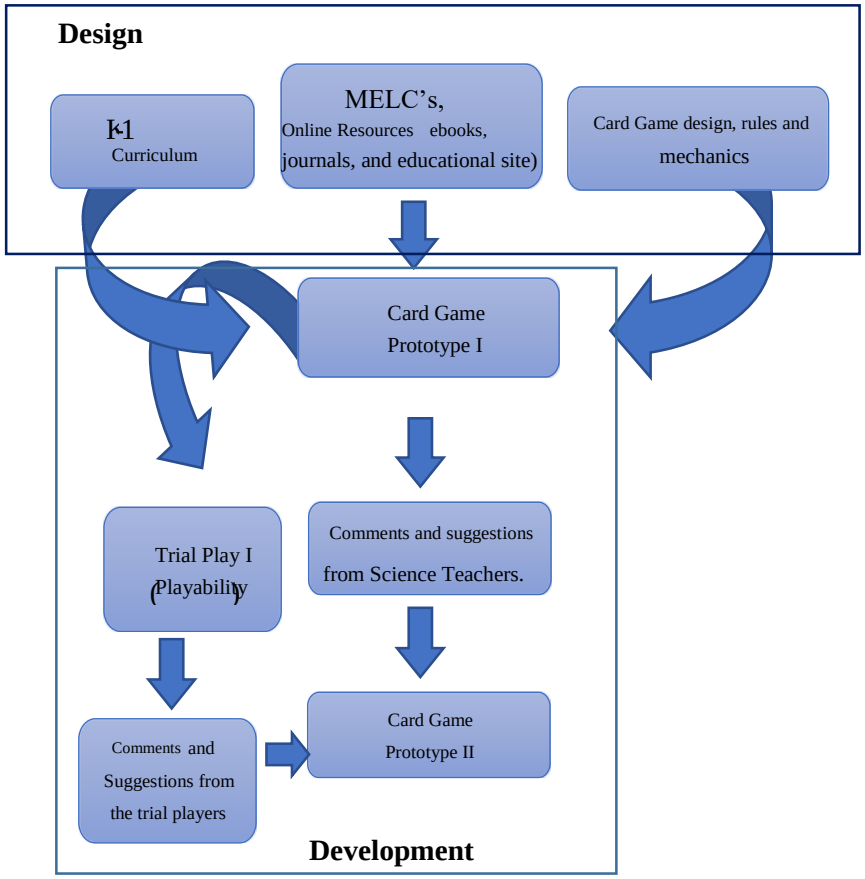
Task Evaluation - A questionnaire that was adapted and modified from Intrinsic Motivation Theory was used to know the students' perception and insights towards the tryout game. The questionnaire has four categories: interest/enjoyment, perceived competence, pressure/tension, and usefulness. This questionnaire is a seven-point scale questionnaire. The researcher modified the one part of the task evaluation, which is the usefulness category, so that it can fit in the card game activity.

K-12 Science Curriculum Guide - The science curriculum guide was used to serve as guide in choosing what and what nots question must be include in the developed card game.

Data Collection

Before conducting the study, the researchers chose a physics topic anchored with the curriculum guide that the students have a hard time learning.

PHASE I. Design and Development of the Card Game



Designing the Card Game

This card game is somewhat similar with Memory Game or Concentration Game. It is a popular card game played by the children and adults around the world. The questions used in the game was taken from the Science textbooks, K-12 Curriculum Guide, and some internet sources. The first design or element we put in the card is inspired by the standard deck of playing cards that consists of four (4) cards in each suit of Spade, Heart, Diamond, and Clubs, see figure 4. After the researcher presented the first design to the adviser, he wanted a unique element in our card game, and so the researchers changed the design into a PvS (plant vs zombie) theme cards, see figure 5. For the second design, it was suggested to come up with an original or own design as elements in the cards, the researchers came up with the third design, see figure 6.

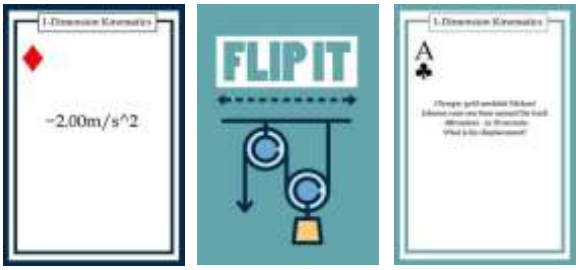


Figure 4 First Card Design

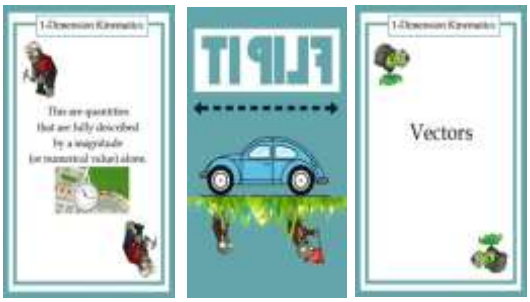


Figure 5 Second Card Design

Figure 6 Third Card Design

Developing the Card Game

Prototype I

The researchers sought the experts' (Science Teachers) opinion, comments, and suggestions of the prototype I of the card game using the Mean Rating Descriptor.

Table 2 is the Mean Rating Descriptors for the ratings of the experts.

4.21 – 5.0	Very Good
3.41 – 4.20	Good
2.61 – 3.40	Fair
1.81 – 2.60	Poor
1.0 – 1.80	Very Poor

Figure 7 Prototype I

Trial Play

A trial play was conducted by the researchers to determine its playability. The players during the trial play are the fourth-year college BSED-Physics student-teachers. As the game goes on, it can be seen that they are enjoying and learning at the same time because they were reminded of their past lesson. Also, they are having difficulty with reading the questions because the font size was too small for them. After getting the comments and suggestions, revision is done to enhance the playability of the game.

Table 3 is the Mean Rating Descriptors for the ratings of the trial players.

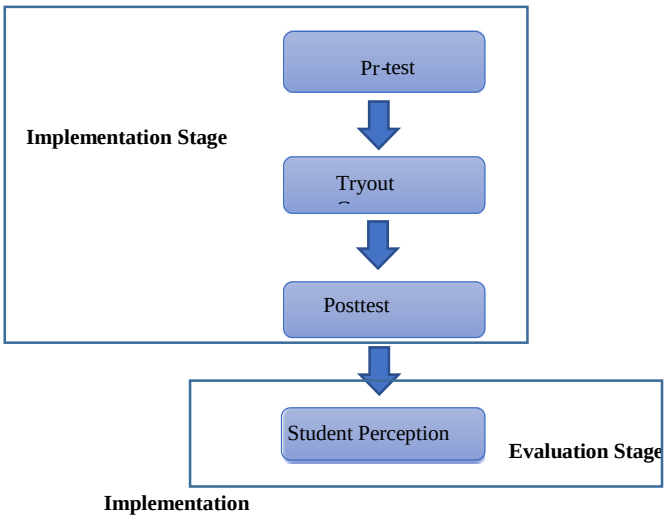
4.21 – 5.0	Very Good
3.41 – 4.20	Good
2.61 – 3.40	Fair
1.81 – 2.60	Poor
1.0 – 1.80	Very Poor

Prototype II

The comments and suggestions gathered from the trial play I helped the researchers to revise and enhance the card game.

Figure 8. Prototype II

Phase II. Implementation and Evaluation of the Card Game



Pretest

A pretest was conducted to determine the student respondents' prior knowledge about One Dimension Kinematics.

Tryout Game

After the pretest, the tryout game follows using the prototype II cards. The game mechanics and procedure were introduced before the game started. The game continues until all cards have been matched and removed from the playing area.

Posttest

After the tryout game, the researchers conducted a posttest to see if there is a significant increase in the students' knowledge about One Dimension Kinematics after playing the tryout game.

Evaluation

Students' Perception

An evaluation sheet was given to the respondents to get or to determine their perception towards the tryout game or the activity.

Table 4. Mean rating for the Student's Perception

1.0 – 2.4	Not at All True
2.5 – 3.9	Somewhat True
4.0 – 5.4	True
5.5 – 7.0	Very True

Final Version

The researchers were able improve the design and made the final version of the card game base from the comments and suggestions gathered from the validation.

Data Analysis

Williams et al. stated that the main reason why students are not interested in learning physics is that they perceive physics to be a difficult/hard subject. Students find physics hard essentially because they have difficulties in solving physics problems. With that being said, the researchers developed a card game anchored in One Dimension Kinematics topic to add fun and interesting factor to the students' learning. The mechanics and design of the card game, materials to be used, and the respondents of the study was then decided to developed the card game. After the development of the card game, the researchers then acquired the evaluation, comments and suggestions from the science teachers in junior high school and senior high school, practice teachers (physics major), and respondents for further development of the card game.

All respondents were given a consent form as a written approval for their participation in the research. The main purpose of the form is to certify the respondents that their involvement in the said research is voluntary. The researcher informed the respondents about the objectives and purpose of the study.

The data gathered were coded. The science teachers coded as ST, hence, ST1 refers to the science teacher respondent number 1, and so on. The senior and junior high school students will be coded as S, hence, S1 refers to the student respondent number 1, and so on.

Table 5 Coding of Science Teachers

Respondents	Code
Science Teacher 1	ST1
Science Teacher 2	ST2

Table 6 Coding of Students

Respondents	Code
Student 1	S1
Student 2	S2

Statistical Method

Mean

Weighted mean was used to express the field experts 'evaluation of the developed educational card game. To interpret the ratings, the following descriptions were used: 1.00-1.80 (Very Poor); 1.81-2.60 (Poor); 2.61-3.40 (Fair); 3.41-4.20 (Good); and 4.21-5.00 (Very Good).

Normalized Gain

This was used to determine if there is a significant difference towards the perception of the students in using the card game.

$$< g >= \frac{(post\ test\ score - pre\ test\ score)}{(perfect\ score - pre\ test\ score)}$$

Table 7 Normalized gain

Normalize Gain Score	Interpretation
g<0.30	Low
0.31<g<0.70	Medium
0.71<g<1.00	High

RESULTS AND DISCUSSION

Design Stage

This card game is somewhat similar with Memory Game or Concentration Game. It is a popular card game played by the children and adults around the world. The questions used in the game was taken from the Science textbooks, K-12 Curriculum Guide, and some internet sources. Elements, such as stars are added to the cards that will also be the bases of the scores. This game will need 5-10 players. The cards composed of a 40-card deck with varying numbers and colors of stars. The red stars indicate the bonus questions. One yellow star indicates easy questions and equivalent to one point, two yellow stars indicates average questions and equivalent to two points.

Lastly, the three yellow stars indicate hard questions and equivalent to three points.

Development of the Card Game

After designing the card game, an evaluation form was given to the science teachers to rate the developed card game to determine its strengths and weaknesses.

Evaluation of the Educational Card Game by The Science Teachers

Table 8 presents the results from the evaluation. The evaluation was divided into five main categories the goals and objectives, the card design, the components and organization, the playability and playfulness, and the usefulness. It can be seen from the table below that teachers' find the goals and objectives, card design, components and organization, playability and playfulness, and usefulness as 'Very Good'. Furthermore, they also find the item 16 as 'Good'. Item 16 refers to the time duration in playing the game. Overall, the teachers rated the card game as 'Very Good'.

Table 8: Descriptive Evaluation of Teachers on the Developed Card Game

	ITE MS	Weighted Mean	Interpretation
Goals and Objectives			
1	The purpose and rationale for the game are fully explained.	4.76	Very Good
2	The goals and objectives of the game are clearly defined.	4.88	Very Good

Table 8: Descriptive Evaluation of Teachers on the Developed Card Game			
	ITE MS	**Weighted Mean**	**Interpretation**
3	The game was thought provoking.	4.65	Very Good
4	The game encouraged student interaction.	5	Very Good
5	The game promoted discussion of key topics.	4.78	Very Good
6	The card game helps with my recall of concepts/terms.	4.80	Very Good
Average Mean		**4.81**	**Very Good**
Card Design			
7	Card size is appropriate.	4.77	Very Good
8	Having terms printed on all four sides of the card is a helpful feature for the players' handling of the cards.	4.80	Very Good
9	The picture printed on the card is representative of the topic.	4.70	Very Good
10	The material used (paper) in the preparation of the cards is durable.	4.88	Very Good
11	The deck of cards is compact and can be easily carried around.	5	Very Good
Average Mean		**4.83**	**Very Good**
Components and Organization			
12	The directions were clear, concise, and easily understood.	4.78	Very Good
13	The game emphasized key points of the topic played.	4.87	Very Good
14	The terms used were appropriate to my level of knowledge.	4.96	Very Good
15	The number of cards was appropriate.	4.87	Very Good
16	The length of time required to play the game is reasonable.	4	Good
Average Mean		**4.7**	**Very Good**
Playability and Playfulness			
17	The game provides opportunity for healthy competition and cooperation.	4.87	Very Good
18	The rules of the game provide players with equal conditions for a fair play.	4.87	Very Good

Table 8: Descriptive Evaluation of Teachers on the Developed Card Game			
	ITE MS	**Weighted Mean**	**Interpretation**
19	The rules of the game provide a set of options for flexibility in making decisions when playing the game.	4.8	Very Good
20	Playing the game was fun.	4.93	Very Good
Average Mean		**4.87**	**Very Good**
Usefulness			
21	The game was effective in reviewing	4.8	Very Good
	the material.		
22	The game encouraged the players to dig deeper into the subject matter.	4.53	Very Good
23	Playing the game is a productive use of time.	4.87	Very Good
24	Playing the game help me establish better relationships with the members of the group.	4.8	Very Good
25	I would recommend the game to my peers.	4.87	Very Good
Average Mean		**4.77**	**Very Good**
Overall Mean		**4.8**	**Very Good**
Legend: Very Good ~ 4.21-5.0 Good ~ 3.41-4.20 Fair ~ 2.61-3.40 Poor ~ 1.81-2.60 Very Poor ~ 1.0-1.80			

Thus, the developed card game was enhanced based on the comments and suggestions given by the science teachers. Here are some of the comments and suggestions of the science teachers.

ST5: Just make sure that the images and text will be visible in the cards

ST2: Classify your questions according to the level of your questioning (easy, average, difficult and bonus)

ST1: Shorten the sentences in the mechanics because there is a tendency that the student will no longer read it

ST3: Sand time is not accurate at all times. It is a very good supplementary learning materials for the learners.

Trial Play

The researchers conducted a trial play to determine its playability. The players during trial play are fourth year college Physics students. Here are the comments and suggestions during the trial play.

Comments

- *Engaging*
- *Makalingaw*
- *Dapat paspas mka huna-huna*
- *The font size of the card is too small*
- *Very helpful*

Suggestions

- *The timer should be digital*
- *Murag walay pulos ang dice, better not to have it and decide kinsa ang una before mag start ang game like bato-bato pick.*
- *Make the font size bigger*
- *Revised the questions that can be easily understood to the target participants*
- *Make the mechanics simple and easy to understand*

Based on the comments and suggestions gathered from the trial play, the researcher should create a bigger font and size of the card so that the game can be more visible. Also, the game mechanics and the sentence structures in the questions are enhance.

Figure 9 *Comparison of Card Game Prototype I and Prototype II*

Implementation Stage

The implementation of the developed card game started with a pretest to determine the prior knowledge of the students. It was then followed by the tryout game or the card game activity, where students played the game. After the tryout game, a posttest was given to the students to determine the level of learning they have acquired by playing the game. Lastly, a task evaluation was given to them to know their perception towards the card game activity. Twenty-three (23) grade 10 students played the try out game.

Performance of the Students towards the Try-out Game

The researcher conducts the try out game on the twenty-three Grade 10 students to determine the effectiveness of the developed card game. The researcher wanted to know the performance of the students in learning One Dimension Kinematics and if there is a significant difference between the normalized gain by each student.

Table 9 Performance of the Student Participants in Pretest and Posttest During the Tryout Game

Score	**Pre-test**		**Post-test**	
	Frequency	**%**	**Frequency**	**%**
1-5	14	60.87**%**	0	0
6-10	9	39.13**%**	8	34.78**%**
11-15	0	0	11	47.82**%**
16-20	0	0	4	17.39%
Total	23	100	23	100

Table 9 shows the performance of the student participants during the pre-test and post-test. As seen in the table, the pre-test results showed that 60.87% of the student participants had a score ranging from 1-5, 39.13% had a score ranging 6-10, and none of students' participants had a score ranging from 11-20. This implies that the students got the lowest scores in pre-test.

In the post-test results showed that 34.78% of the student participants had a score ranging from 6-10, 47.82%had a score ranging from 11-25, and 17.39% had a score ranging from 16-20, and none of the student participants had a score ranging 1-5. Base on the result after playing the game, most of the students had an increase in their scores.

Table 10 shows the scores gained by the students during pre-test and post-test. It also showed the individual normalized gain of the students during the try out game. In the study of Hake (1999), he categorized the normalized gain into three categories which are low g ($g < 0.3$), average g ($0.7 > g > 0.31$), and high g ($g > 0.71$) in measuring the increment of the students' performance after an intervention like an activity, lecture, etc. As seen in table 3, there are two (2) students or 8.70% of the total number of the participants belongs to the high g (normalized gain), fifth teen (15) or 65.22% of the participants belongs to average g, and there are six (6) or 26.09% of the participants belongs to low g. Those students who have a high g indicate that there is a substantial development of the students' performance during the post-test. Those who belong to average g have an intermediate development, and those who belong to low g have a moderate increase in their performance during post-test. This denotes that there is a significant increase in the performance of the students in learning One Dimension Kinematics after the try out game.

Table 10 Individual Normalized Gain of the Students

STUDENTS	PRE TEST SCORE	POST TEST SCORE	Individual Normalized Gain of the Students	Interpretation
S1	7	12	0.38	Medium
S2	3	9	0.18	Low
S3	3	12	0.59	Medium
S4	4	10	0.53	Medium
S5	5	14	0.60	Medium
S6	4	10	0.69	Medium
S7	7	13	0.46	Medium
S8	9	15	0.55	Medium
S9	3	10	0.41	Medium
S10	9	20	1	High
S11	5	11	0.4	Medium
S12	5	12	0.46	Medium
S13	9	14	0.45	Medium
S14	6	10	0.28	Low
S15	2	8	0.33	Medium
S16	10	17	0.30	Low
S17	3	13	0.59	Medium
S18	7	11	0.31	Medium
S19	5	16	0.27	Low
S20	10	17	0.30	Low

STUDENTS	PRE TEST SCORE	POST TEST SCORE	Individual Normalized Gain of the Students	Interpretation
S21	3	8	0.29	Low
S22	5	15	0.71	High
S23	3	13	0.59	Medium
Overall Mean	**5.52**	**12.61**	**0.46**	**Medium**

Evaluation Stage

Perception of the Students towards the Tryout Game

After the post-test, a task evaluation was given to the students to get their perception and insight towards the game. This questionnaire is a 7-point scale questionnaire. The activity task evaluation has four categories which are interest/enjoyment, perceived competence, pressure/tension, and usefulness.

Table 11 shows the perception of the students towards the try out game. In the interest/enjoyment category the students rated it mostly as a "Very True" except the 'I thought this was a boring activity' and 'This activity did not hold my attention at all', these two items in the interest/enjoyment category were rated as "Not at All True." This implies that the students enjoyed the game. In the perceived competence category only the 'This was an activity that I couldn't do very well' got a "Not at All True" rate and others were rated as "Very True" and "True." Based on the rating of the students in this category, it only implies that in playing the card game they can perform or do it well. In the pressure/tension category the students rated two items as "Very True" and the rest rated as "Not at all True." This category showed that students who were playing the game did not feel nervous and was very relaxed in doing the said activity. Lastly, in the usefulness category, the students rated it as "Very True" which implies that using the developed card game is helpful and useful for students.

Table 11 Perception of the Students Towards the Developed Card Game

Category	Scale							Mean	Interpretation
	1	2	3	4	5	6	7		
Interest/Enjoyment									
I enjoyed doing this activity very much					1	2	20	6.83	Very True
This activity was fun to do					1	19	3	6.18	Very True
I thought this was a boring activity.	4	15	2	2				2.09	Not True at all
This activity did not hold my attention at all.	12	11						1.48	Not at all True
I would describe this activity as very interesting.						5	18	6.78	Very True
I thought this activity was quite enjoyable.					4	10	9	6.23	Very True
While I was doing this activity, I was thinking about how much I enjoyed it.					1	9	13	6.52	Very True

Category	Scale							Mean	Interpretation
	1	2	3	4	5	6	7		
Perceived Competence									
I think I am pretty good at this activity					2	10	11	6.39	Very True
I think I did pretty well at this activity, compared to other students			1	7	5	8	2	5.13	True
After working at this activity for a while, I felt pretty competent.				2	2	5	14	4.22	True
I am satisfied with my performance at this task.				1	1	2	19	6.69	Very True
I was pretty skilled at this activity	1	1			5	12	4	5.51	Very True
This was an activity that I couldn't do very well	9	9	5					1.82	Not at all True
Pressure/Tension									
I did not feel nervous at all while doing this	1				3	7	12	6.7	Very True
I felt very tense while doing this activity.	19	3	1					1.22	Not at all True
I was very relaxed in doing these.						2	21	6.91	Very True
I was anxious while working on this task.	18	4	1					1.26	Not at All True
I felt pressured while doing these.	17	5		1				1.35	Not at All True
Usefulness									
I believe that doing this card game activity could be useful in understanding the concepts and terms of One Dimension Kinematics						1	22	6.96	Very True
This card game activity is important for a student like me.						3	19	6.56	Very True
This card game activity could improve my study habits.				1	2	10	10	6.26	Very True
I believe doing this card game activity could help me do better in school.					1	2	20	6.83	Very True
Legend: 5.5-7.0 ~ Very True, 4.0-5.4 ~ True, 2.5-3.9 ~ Somewhat True, 1.0-2.4 ~ Not at all True									

Here is the summary of the comments of the respondents:
S5: The game was very fun and enjoyable.
S7: It would be better if there are a greater number of groups playing the game.
S10: Challenging sya and at the same time knowledgeable.

Final Version

The researchers were able improve the design and made the final version of the card game base from the comments and suggestions gathered from the validation.

CONCLUSION AND RECOMMENDATIONS

Summary of the Findings

Based on the findings of this study are summarized and as follow:

1. The developed card game covered the concepts of One Dimension Kinematics. The overall rating of the developed card game was rated as “Very Good” by the science teachers.
2. The developed card game can be a supplemental material in understanding One Dimension Kinematics based from the comments and suggestions given by the science teachers.
3. There is a significant increase in the performance of the student participants during the pre-test and post-test which implies that there is an intermediate increase of their performance after an intervention.
4. The evaluation of the student participants to the developed card game in terms of goals and objectives, card design, components and organization, playability and playfulness, and usefulness was “very good”.
5. The motivation of the student participants after the try out activity showed a positive remark in terms of interest/enjoyment, perceived competence, pressure/tension, and usefulness.

Conclusions

Based on the findings of the study, the following conclusions are drawn:

1. The used of developed card game is a useful tool in learning One Dimension Kinematics. It is also enjoyable, challenging, engaging, interactive, interesting, and knowledgeable.
2. The utilization of game-based learning (GBL) in teaching and learning process can enhance, engage, and motivate students in learning a specific subject.

Recommendations

1. The study can be improved by utilizing the card on the target respondents which is for Grade 12 students.

2. The design, rules, mechanics and materials of the developed card game can be further enhance by laminating the cards, making use of card holder and by printing mechanics in a separate paper just like a guide.

3. Future studies may be conducted by other departments with a different science topic and other subjects.

4. Future researchers may modify the DepEd Module by utilizing the card game as a part of an activity in the DepEd Module.

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