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Element and Ladder Board Game (E-Lab Game): Enhancing Student Mastery in Determining the Number of Protons, Electrons and Neutrons of an Atom

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Charmayne D. Romero[1], ORCID No. 0009-0001-2408-0418
Crystal L. Bastian[1]
Monique B. Iyadan[1]

[1]Master of Arts in Teaching Science, College of Advanced Education, Ifugao State University, Ifugao, Philippines

Abstract

This study aimed to evaluate the effectiveness of the Element and Ladder Board Game (E-LaB Game) as an intervention tool in enhancing Grade 8 students' mastery of determining the number of protons, electrons, and neutrons of an atom. A quasi-experimental research design was utilized, involving 12 purposively selected Grade 8 students from Rufino I. Chungalao Science High School (RICSHS), Ifugao, Philippines, during the school year 2024-2025. The selected respondents were divided into two groups: an experimental group, which used the E-LaB Game, and a control group, which followed conventional teaching methods. A 30-item validated identification test was administered as both a pre-test and post-test to assess learning gains. Statistical tools such as paired t-tests, independent t-tests, and effect size calculations (eta squared) were employed for data analysis. Results revealed that students who used the E-LaB Game demonstrated a remarkable improvement in their ability to determine the number of protons, electrons, and neutrons. Statistical analysis showed a significant difference in students' performance before and after using the E-LaB Game, confirming its effectiveness as a learning and remediating tool to enhance their mastery in determining the number of protons, electrons, and neutrons. Based from the findings, it is recommended that more Element and ladder Board Game (E-LaB GAME) learning activities will be employed to reinforce the performance of the Grade 8 students to the number of protons, electrons and neutrons. To future researchers, the E-LaB GAME may be localized in order to be suitable and presentable to learners in a way that is more facilitating, stimulating, and exciting for the learners and become enthusiastic and eager to learn. In addition, to improve the reliability and generalizability of the research findings, consider increasing the sample size by adding more respondents.

Keywords: Element and Ladder Board Game (E-LaB Game), least mastered competency, Science, protons, electrons, neutrons

INTRODUCTION

Teaching students of today's generation has been a perennial challenge for teachers, particularly in providing these students with the core competencies to be more globally competitive and functionally literate in Science.

The Periodic Table of Elements is central to the study of modern Physics and Chemistry; however, it is considered by teachers as difficult to teach. The PTE forms part of high school and tertiary level chemistry, hence it is the foremost core to the study of modern science. In South Africa, PTE is a topic introduced to students at the secondary level; nevertheless, for many Physical Sciences teachers, this topic is considered challenging to teach because several studies reported that the majority of teachers experience difficulties when teaching science content at secondary school level (Mokiwa, 2017). This is due to the student's ability on comprehension and classroom practices to ignite the interest of learners and inculcate them a positive attitude towards Science. When an instructional approach does not fit the learners' needs and interest, they face a dilemma that would result in "No Mastery" of the competencies and that would make the acquisition of learning difficult for them (Malana, 2020). Moreover, students' diverse needs, interests, and learning abilities pose a

problem to effectively manage the class and this challenges the teachers to provide varied activities, innovations, teaching approaches, and methodologies that would not only fit to one learner but also to the whole class (Abana, 2021).

One of the goals of implementing the K - 12 Basic Education Program is to create and produce a functional basic system that will produce productive and responsible citizens equipped with essential learning, and employment and to be at par with other countries. This is in line with the agenda of President Aquino of having quality education as a long-term solution to poverty. The K - 12 Education vision from the Department of Education (DepEd, 2010) every graduate of the Enhanced K - 12 Basic Education Program is an empowered individual who has learned through a program that is rooted on sound principles and geared towards excellence. Science literacy among students is increasingly vital in today's world, especially as we prepare future generations to navigate complex global challenges that they may encounter. Issues such as climate change, food insecurity, public health crises, and the spread of misinformation demand that young learners develop critical thinking, problem-solving, and evidence-based decision-making skills. The ability to understand and apply scientific principles is no longer just an academic necessity—it is a fundamental life skill that will mold the future of societies. Through prioritizing science education, we can give students the knowledge and tools they need to address real-world problems, contribute to technological advancements, and make informed choices in their daily lives.

However, the Philippines has consistently been identified as one of the countries with low levels of science literacy, as evidenced by results from various local and international assessments over the years. Studies and standardized tests have highlighted persistent challenges in students' understanding of scientific concepts, problem-solving skills, and application of scientific knowledge. Filipino students' poor achievement levels in Science have been documented for several years now. In 2015, the National Achievement Test in Science showed a mean score of 39.5%; only 1.8% of the students attained mastery levels of science curriculum goals. These low achievement levels are also documented in international assessments of Science Education on the Trends in International Math and Science Study (Mokiwa, 2014). In addition, this problem was heightened by the release last December 2019 of the results of the 2018 Programme for International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD). The performance of the country in the recent PISA confirms the unexpressed suspicion that there is a long-standing problem of quality of education in the country. Among 79 high- and middle-income countries, the country was last in reading, and second to last in Mathematics and in Science (Acido & Caballes, 2024)

Moreover, the pattern of Filipino students' performance in PISA 2018 matches their achievement in another international assessment, the Trends in International Mathematics and Science Study (TIMSS). Similar to PISA, TIMSS measures students' ability to apply their knowledge in different content areas of science. Performance was evaluated using benchmarks, each with a corresponding scale score: Low (400), Intermediate (475), High (550), and Advanced (625) (Mullis et al., 2020).Several studies pointed out that teaching innovation is when teachers use multi-faceted and lively teaching methods, diversified and rich content to stimulate students' inner interest in learning; thus, developing positive student attitudes towards proactive learning and enhancing students' learning ability is an inevitable result to be divulged (Malana, 2020).

The Element and Ladder Board Game (E-LaB Game) was adapted from the classic Snakes and Ladders board game, with few modifications designed to serve as a remediation tool for enhancing students' mastery of determining the number of protons, electrons, and neutrons in an atom. While the original Snakes and Ladders game is purely

recreational, the E-LaB Game includes educational elements, transforming it into an engaging and interactive learning experience. In this version, students' progress through the board by correctly answering questions related to atomic structure. Instead of merely rolling dice and moving tokens, players must determine the number of protons, electrons, and neutrons in given elements to advance. Correct answers allow players to climb ladders, reinforcing positive learning experiences, while incorrect answers may result in setbacks, encouraging students to review and reinforce their understanding. By gamifying the learning process, the E-LaB Game makes the concept of atomic structure more accessible and engaging, helping students visualize and internalize the relationships between protons, electrons, and neutrons. Protons and electrons define the element's identity and charge, while neutrons contribute to atomic mass, making their accurate determination fundamental in chemistry. The game not only enhances student engagement and motivation but also strengthens their conceptual grasp of atomic structure, leading to better retention and mastery of the subject matter.

Statement of the Problem. This study was conceptualized to assess the effectiveness of E-LaB Game. Additionally, it is also focused on understanding how E-LaB Game improves the learners' mastery of concepts as well as the perceived effectiveness of the intervention material to the learners. Specifically, this study aimed to answer the following questions:

1. What are the mean pre-test scores of the respondents in each control and experimental group before the use of the "E-LaB Game"?

2. What are the mean post test scores of the participants in each control and experimental group after the use of the "E-LaB Game?"

3. Is there a significant difference between the mean pre-test and post-test of each group?

4. Is there a significant difference between the mean pre-test and post-test of the two groups?

5. What is the effect size of implementing an E-LaB Game in identifying the number of protons, electrons and neutrons of an atom in the academic performance of the respondents?

METHODOLOGY

Research Design. This study utilized a quasi-experimental design to evaluate the effectiveness of the Element and Ladder Board Game (E-LaB Game) in improving the mastery of Grade 8 students in identifying the number of protons, electrons, and neutrons of an atom to allow for a comparative analysis of the effectiveness of the Element and Ladder Board Game (E-LaB Game).According to Harris A. et.al.(2006),quasi-experiments are studies that aim to evaluate interventions and aim to demonstrate causality between an intervention and an outcome.

Research Respondents. The study was conducted at Rufino I. Chungalao Science High School (RICSHS), located in the municipality of Aguinaldo, in the province of Ifugao, Philippines. The respondents were 12 purposively selected Grade 8 students chosen based on their low performance in Chemistry. They were divided into two groups: an experimental group that used the Element and Ladder Board Game (E-LaB Game); and, a control group which followed conventional teaching methods. The study involved only 12 respondents due to the low number of enrollees for that particular grade level. Due to the small class size, it was not feasible to include a larger sample. However, the study still aimed to assess the effectiveness of the E-LaB Game in improving mastery of the concepts among the selected students.

Research Instrument. The study used a validated, teacher-made 30-item identification test to measure students' mastery. The 30-item identification test was developed and aligned with the competencies outlined in the curriculum and assess students' mastery

through pre- and post-tests. Scoring was based on 1 point for each correct answer and 0 for each incorrect answer, providing a total score out of 30. The questionnaire's validity was ensured through confirming its alignment with the curriculum's competencies, also through evaluating construct validity and reliability through teacher feedback and statistical analysis. Additionally, the Element and Ladder Board Game (E-LaB Game) served as an instructional tool for the experimental group, providing interactive and engaging activities.

Data Gathering Procedures. The selected 12 learners took the pre-test and post-test. The data were gathered from the result of the pre-assessment using the 30-item teacher-made Pre-Test and Post-Test that underwent validation. Permissions were obtained from the school administration, teachers and students to ensure ethical compliance. The pre-test was administered to both the experimental and control groups to establish baseline knowledge, followed by a two-week intervention where the experimental group used the Element and Ladder Board Game (E-LaB Game) while the control group followed conventional teaching methods. After the intervention, a post-test was conducted, and the data collected were analyzed using statistical tools.

Statistical Analysis. The data collected from the pre-test and post-test scores of both the experimental and control groups were analyzed through the following statistical tools:

1. To assess the significance of the improvement within each group, a paired t-test was conducted to compare their pre-test and post-test scores.

2. An independent t-test was used to compare the post-test scores of the experimental and control groups to identify any significant differences in learning outcomes.

3. Additionally, effect size (eta squared) was calculated to determine the magnitude of the intervention's impact on the experimental group's academic performance.

Ethical Consideration. The researchers ensured that the study will not inflict mental, emotional, and health problems to the respondents. Thus, the consent of the respondents and permission from the parents, teachers and principal were considered prior to the conduct of the study.

RESULTS AND DISCUSSION

Table 1 shows the mean pre-test scores of the respondents in each of the control and experimental groups before the use of E-LaB GAME. The study presents the number of respondents in each group with a total of 12 participants. Mean and standard deviation were administered. It revealed the level of students' performance in Science 8 on the least learned competencies which says that the Pre-test score of the 12 respondents on the least mastered competency is below the mastery level.

In this study, the pre-test of the control group got M=5.5 SD= 3.39 while the experimental group got M=2.67 SD= 1.63. Based on the results, the students have difficulties in determining the number of protons, electrons, and neutrons of an atom. This is in parallel with the findings of Bahar, Johnstone, and Hansell (1999) that the periodic trends, ions, and the history of the periodic table were the science aspects that proved to be the most troublesome.

Table 1
Pre-test mean of the control and experimental groups before the use of E-LaB GAME.

Number of Students	Control Group	Experimental Group
1	8	1
2	9	4
3	5	5
4	1	3
5	2	2
6	8	1
Mean	5.5	2.67
S.D.	3.39	1.63

Table 2
Post-test mean scores of the control and experimental group after the E-LaB GAME.

Number of Students	Control Group	Experimental Group
1	10	30
2	12	30
3	18	28
4	20	29
5	14	30
6	20	30
Mean	15.67	29.5
S.D.	4.27	0.84

Table 2 shows the level of students' performance in Science 8 on the least learned competencies. Using the same statistics in table 1, the mean pre-test scores of the control group was 15.67 with a standard deviation of 4.27, whereas the experimental group had a mean of 29.5 with a standard deviation of 0.84. It clearly reflects that there is a remarkable increase in the mean of the respondents after the utilization of the Element and Ladder Board Game on the identified least mastered competency. This means that the performance of the students positively responds to the utilization of E-LaB GAME. Bacatan et al. (2022) also supported the findings which defined the Strategic Instruction Model (SIM) as means to re-teach the concepts and skills (least mastered). It is a material given to students to help them master competency-based skills which they were not able to develop during the regular class.

Table 3
Test of difference between the pre-test and post-test of the control and experimental group, using paired t-test.

N	Mean	t-value	p-value
Control Group	15.67	-7.78	.000
Experimental Group	29.5		

As shown in Table 3, the significant difference on the paired sample t-test based on the mean pre-test and post-test of the two groups was illustrated. Based on the result, it implied that there is a significant difference between the scores in the pre-test and post-test and the students' performance in Science 8 on the least learned competencies in determining the number of protons, electrons and neutrons. This result is supported by Bete (2020) wherein he stated that using SIM (Strategic Intervention Material) can elevate the instructions and students' academic performance for students' mastery of concept. As shown below, it tells the fact that E-LaB GAME helped the students in gaining insights about the topic.

Table 4
Test of difference between the posttest of the control and experimental group, using independent t-test.

	Pre-test			Post test		
	Mean	t-value	p-value	Mean	t-value	p-value
Control Group	5.5	1.84	0.095	15.67	7.13	0.00
Experimental Group	2.67			29.5		

Table 4 shows the significant difference between the control and experimental groups. It indicates that the mean score of the control group in terms of pre-test is 5.5 while 15.67 has been recorded in terms of the post-test. On the other hand, the experimental group has a pre-test mean of 2.67 and a post-test mean of 29. 5. It unfolds that there is a significant difference between the post-test of the control and experimental groups. The findings of this study were confirmed in the studies conducted by Bangayan-Manera (2019) which says that strategic intervention materials are highly regarded as tools for remediating poor achievements of the learners. SIM or Strategic Intervention Material refers to a teaching aid introduced as a teaching method to stimulate the activity of the students and thereby increase their level of understanding. Using varied strategies and teaching styles is really helpful on the part of the teachers and even students. Indeed, quality teaching will be shared, and quality output would be expected from the students.

Table 5
The effect size of E-LaB GAME as an intervention.

N	t-value	Eta2	Remarks
12	7.13	.9501	Large Effect size

Based on Table 5, using eta squared, the computed effect size between the pre-test and post-test of the experimental group is .9501. This indicates that the intervention has a very large impact on the improvement of scores of the experimental group as a whole. According to the study of Gonzalez (2016), game-based instructional materials offer proven benefits for student engagement and academic performance in a general science course that results to higher scores among students when compared with those achieved by students following a traditional classroom setting.

Conclusion. Based on the results of the study, the E-LaB Game significantly improved Grade 8 students' mastery in determining the number of protons, electrons, and neutrons in an atom, as evidenced by a substantial increase in the mean scores from pre-test to post-test. The game proved more effective than conventional teaching methods in addressing challenges related to conceptual understanding and procedural knowledge. Moreover, the intervention had a large effect size, demonstrating its effectiveness as a pedagogical tool for improving student performance in science.

Recommendations. In view of the findings drawn from the study, the following are the recommendations:

1. Teachers who want to adapt the E-LaB Game can enhance the learning experience by adding rules and modifying mechanics to better suit their curriculum and engage students. Customizing the game's structure will create a more enjoyable and effective eLearning environment while promoting active participation.

2. The students may use the E-LaB Game at any time to enhance their problem-solving skills in determining the number of protons, electrons, and neutrons of an atom.

3. For administration, teaching-learning Science may help the learners within blended learning associates with available printed materials. Additionally, it allocates the period of the lesson proper in its suitable span of teaching and learning of students.

4. Since the researchers had respondents of only 12 Grade 8 students, it is recommended to the future researchers to at least have 30 respondents or more in order to have a more accurate result.

5. For future researchers, the E-LaB Game contents, presentations, and evaluations may be localized and be made suitable for the learners; and, presentable in a way that is more facilitating, stimulating, and exciting for the learners to be enthusiastic and eager to learn.

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