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Evaluating the Effect of the Game of Cards (GoC) Strategy on Improving Grade 10 Student's Problem-Solving Skills in Boyles and Charles` Gas Laws: A Pretest and Posttest Quantitative Study

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ABSTRACT

Physics is the discipline that studies the principles of matter and energy, as well as their interactions. Mechanisms, electricity and magnetism, heat and thermodynamics, optics, and acoustics are among the fundamental concepts in Physics. Each of these conceptions has its own set of fields and fundamental laws. Furthermore, the researchers utilized purposive sampling in selecting the participants. Quasi-experimental research design was used in the study. Two groups were determined in the study, the control and experimental group. The control group used a lecture/traditional method while the experimental group had an intervention. The study utilized statistical tools to support the data gathered. Using the Mean test, results revealed that . The Paired sample t-test strongly indicates that the improvement in students' performance from pretest to posttest is statistically significant. Paired sample t-test is also utilized to determine if there is a significant difference in the mean pretest and posttest score of each of the two groups. Thus, the results of the control group revealed that the null hypothesis is rejected. The Eta squared is administered and the results confirm that the intervention (GoC strategy) had a large effect on student performance. The Game of Cards (GoC) was created to assist students grasp and recall basic physics ideas while also improving their problem-solving skills. Card games can be fun and engaging ways to promote physics instruction at all levels of education. The activities of Game of Cards (GoC) are as follows: a. Guide Card, B. Activity Card, and c. Assessment Card. The intervention has steps with activities regarding Boyle's and Charles's Gas Laws, a specialized topic for Grade 10 students, that build on each other to produce a students-centered educational resources as well as a way of evaluation. Teachers may also consider adapting the strategy for other topics to see if similar improvements can be achieved.

Keywords: Game of Cards Strategy, Pretest and Posttest Experimental Group

INTRODUCTION

Rationale

Science literacy is widely recognized as critical to modern society's economic progress and social involvement (Minister for Education, STEM Education Report, 2016). Several European countries have emphasized the importance of providing equal and effective science education in order to encourage more students at all levels to pursue science degrees. As a result, a number of recent studies have looked into why students choose science-related disciplines at all levels, especially physics. Despite the importance of physics in comprehending the world around us and the fact that it is the foundation of many other sciences, researchers have noted a decline in interest in the subject at all levels when compared to other science courses.

A study of several science topics in Ireland reveals that much fewer Irish post-primary pupils enroll in physics than chemistry or biology. For example, between 1990 and 2010, the percentage of people who took the physics leaving certificate fell from 20% to 12%. (Information retrieved from the State Examinations Commission, 2018). Furthermore, there is a significant disparity in the number of Irish junior cycle teachers with a recognized physics certificate. As a result, out-of-field teachers who do not have a physics degree or background are teaching this topic in secondary school (Ingersoll, 2002). The majority of junior cycle science

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teachers have a biology certificate, which may contribute to biology's popularity as a Leaving Certificate subject of choice (Minister for Education, STEM Education Report, 2016).

As a result, a substantial number of research on the teaching and learning of physics in Ireland has been published in recent years. As a result, a number of research-based teaching materials have been created that demonstrate how approaches that actively involve students have a greater impact on students' knowledge and identity construction. Problem-based learning, collaborative learning (Chance & Bowe, 2015), and the use of video hooks in a physics classroom were among them (McHugh & McCauley, 2016). Secondary students in Ireland, on the other hand, regard physics as a tough subject with a significant conceptual mathematics workload and a primarily masculine subject (Politis, Killeavy, & Mitchell, 2007). Thus, resources that connect learning outcomes as well as students' prior experiences are needed in physics education to generate opportunities for learners to engage with physics and improve the learning process.

The expanded research of Game-Based Learning (GBL) in the classroom has resulted from the search for innovative approaches to improve science teaching and learning, as well as the growing popularity of games. Researchers and educators alike are increasingly convinced of games' strong potential to aid science learning (Morris et al., 2013) and to drive good changes in the school curriculum (Barton et al., 2018; Smith & Munro, 2009). This practice has also been found to boost social growth and collaborative abilities (Berland & Lee, 2012; Azizan et al., 2018).

In the classroom, games are frequently used to teach physics theories and concepts, but there has been less research on games that may be used to educate scientific reasoning. According to studies, educators and academics alike face numerous obstacles when it comes to using games to teach science, including procedural issues in game design and a lack of training on how to use games in the classroom. To solve this problem, the game development framework given here offers a basic guidance on how to integrate learning concepts in board game design, which may lead to improved engagement and academic success in Physics education.

Virtual worlds are an excellent way for learners to learn about motion, gravity, music, light, magnetism, and other concepts. Young kids will be able to create, toss, push, or even catapult items large and small to see where and how they move with these fantastic physics choices. Students in higher grades will be able to create, test, and iterate challenges based on angular momentum, kinetic energy, and other advanced physics principles.

In the Philippines, according to Philstar Global more than half or 62% of all high school teachers in public schools are teaching subjects they did not major in — a mismatch blamed on the department’s practice of assigning subjects based on availability rather than specialization due to a limited budget for hiring.

Data presented by the Second Congressional Commission on Education (EDCOM 2) before the House basic education panel on Thursday, August 29, also show that over half of all teachers in science have no training in the subject, stoking concerns about how students will fare in the science-focused Programme for International Student Assessment (PISA) test in 2025. These findings were drawn from EDCOM 2's analysis of DepEd data covering around 700,000 of over 900,000 teachers in the public school system. It reflects the latest number of teachers as of school year 2023-2024.

One of the Department of Education's goals is to ensure that no student is left behind. This ensures that all students have an equal opportunity to improve their academic performance and develop their least developed talents.

Thus, the study aims to evaluate the effectiveness of game of cards (GoC) as a strategy on improving students` problem solving skills. Therefore, the competency-based strategic intervention materials address the learners' extremely low performance in developing their least-mastered skills, which include solving problems related to Boyle's and Charles' Gas Laws. Referencing literature from other nations in contrast to the Philippines' situation at the local level, the educational system is suffering from a lack of training in certain subjects and a restricted budget. The Philippines was therefore ranked third from the bottom in science, sixth from the bottom in math, and 77th out of 81 countries in the 2022 Programme for International Student Assessment (PISA). Therefore, the study was developed to benefit teachers and students in making sure that these interventions are

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essential and successful in science subjects, particularly physical science.

THEORETICAL FRAMEWORK

The theoretical framework for this study focuses on constructivist learning theory and problem-solving theory, both of which are essential in understanding how the Game of Cards (GoC) strategy might improve students' problem-solving skills in the context of Boyle's and Charles' Gas Laws.

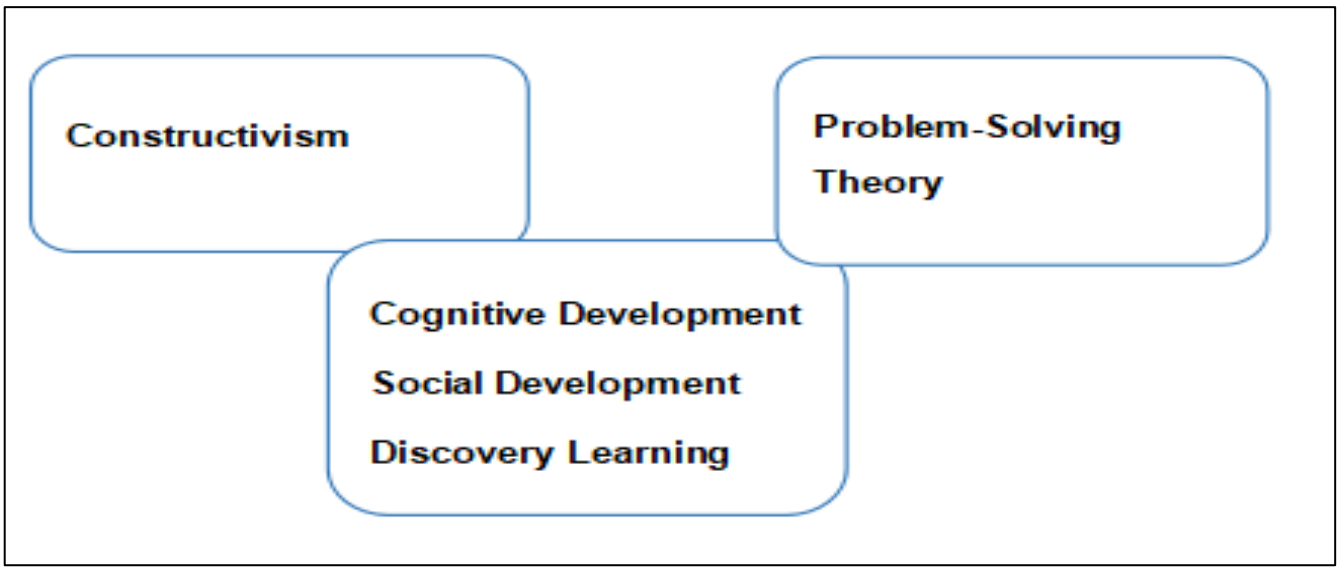

Figure 1: Constructivist Learning Theory (Piaget, Vygotsky, and Bruner)

Constructivist Learning Theory (Piaget, Vygotsky, and Bruner)

Constructivism posits that learners actively construct their understanding of concepts and ideas through experiences and interactions with the world around them. In the context of science education, it emphasizes active learning, where students explore, hypothesize, experiment, and reflect on their findings to build deeper understanding.

1. Piaget's Cognitive Development Theory emphasizes that learners move through different stages of cognitive development, with each stage contributing to more advanced problem-solving skills. Piaget believed that learning occurs when students encounter a challenge that they can only resolve by reorganizing their cognitive structures. By introducing engaging activities like GoC, students may be exposed to situations that help them restructure their existing understanding of gas laws.
2. Vygotsky's Social Development Theory highlights the importance of social interaction in learning. His concept of the Zone of Proximal Development (ZPD) suggests that learners can achieve higher levels of understanding with the assistance of more knowledgeable peers or instructors. The GoC strategy, by encouraging collaborative learning, may provide a ZPD experience for students as they work together to solve problems related to Boyle's and Charles' Gas Laws.
3. Bruner's Discovery Learning emphasizes that learning should be a process where students actively engage with content to discover principles on their own. Through games, students might not only learn about the laws of gases but also develop strategies for problem-solving that could be applied to other scientific and real-world contexts.

Problem-Solving Theory

The problem-solving approach suggests that learning is enhanced when students actively engage in solving complex, real-world problems. This framework aligns with the study's objective of enhancing problem-solving

skills through a structured game-based activity. Polya's Four-Step Problem-Solving Model is central here:

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1. Understanding the problem: Involves grasping the key concepts and relationships, such as the variables in Boyle's and Charles' laws.

2. Devising a plan: Students would use the GoC strategy to develop a structured approach to solving the problem.

3. Carrying out the plan: Solving the problem by applying the principles of gas laws and testing hypotheses.

4. Looking back: Reflecting on the solution and considering alternative approaches to the problem.

Using GoC allows students to engage in this cyclical process and refine their problem-solving skills.

Conceptual and Analytical Framework

The conceptual framework of this study outlines the key variables and their relationships, as shown in Figure 2. The independent variable is the GoC strategy, and the dependent variable is the problem-solving skills related to Boyle's and Charles' Gas Laws.

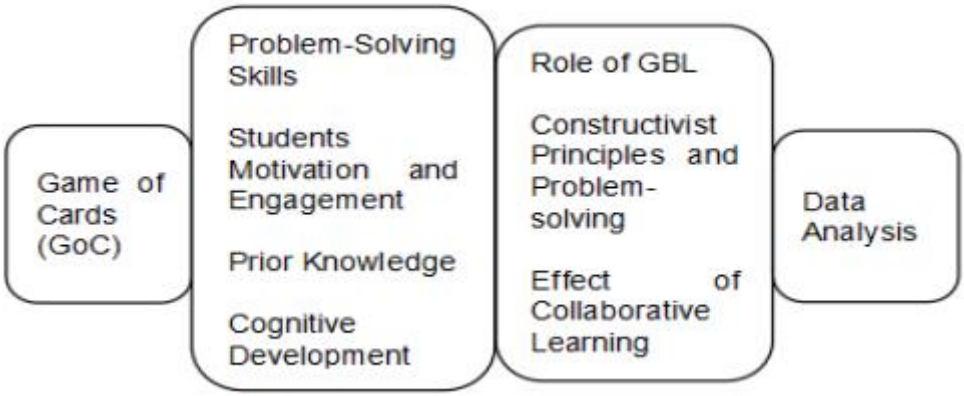

Figure 2: Research Paradigm

GoC Strategy

The Game of Cards (GoC) strategy represents a hands-on, interactive method for engaging students in learning. In this context, it involves a series of challenges or tasks related to Boyle's and Charles' laws that students must solve using cards to simulate variables and equations. The GoC strategy is expected to foster active learning, peer collaboration, and critical thinking, which are essential for problem-solving.

Problem-Solving Skills

Problem-solving skills in the context of Boyle's and Charles' Gas Laws refer to the ability to apply mathematical and scientific principles to interpret and solve problems related to the behavior of gases under varying pressure and temperature. This includes: Analytical skills, the ability to interpret experimental data and identify patterns. Critical thinking, the ability to evaluate different approaches to solving a problem. Mathematical reasoning, applying the correct mathematical formulas and interpreting their outcomes.

Student Motivation and Engagement

The Game of Cards (GoC) strategy can increase student motivation and engagement, two critical factors in enhancing learning outcomes. The interactive and competitive nature of GoC may keep students more involved in the learning process, thus enhancing their problem-solving abilities. Motivation plays a significant role in encouraging students to tackle complex problems, while engagement ensures they remain focused and active throughout the learning experience.

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Prior Knowledge and Cognitive Development

Prior knowledge of physics and mathematics may influence the extent to which students can engage with and

benefit from the GoC strategy. Students with a stronger foundation in related topics are likely to solve problems more efficiently. Cognitive development also plays a role, as students at different stages may experience varying levels of success in solving gas law problems.

The Role of Game-Based Learning in Enhancing Problem-Solving Skills

Game-based learning has shown promise in developing both content knowledge and cognitive skills. According to Gee (2003), well-designed educational games can enhance engagement, increase motivation, and foster problem-solving abilities by providing immediate feedback and opportunities for iterative practice. The GoC strategy, through its competitive and cooperative nature, encourages students to engage deeply with the problem-solving process, making learning more enjoyable and effective.

The Relationship Between Constructivism and Problem-Solving in Physics

The alignment between constructivist principles and problem-solving in physics can be seen in how students learn better when they actively solve problems themselves, rather than passively receiving information. According to Piaget (1972) and Vygotsky (1978), active engagement through hands-on, real-world tasks leads to more meaningful learning experiences. This study builds on these theories by incorporating the GoC strategy to facilitate problem-solving in Boyle's and Charles' laws.

Effect of Collaborative Learning on Student Learning Outcomes

Collaboration, as outlined in Vygotsky's work, plays an essential role in the development of problem-solving skills. By working together in the GoC strategy, students are likely to benefit from shared insights and perspectives, leading to deeper comprehension of complex topics like gas laws. This social interaction can also help build confidence in students, making them more likely to tackle difficult problems independently in the future.

General Objective

To evaluate the effectiveness of Game of Cards (Goc) Strategy by comparing the pretest and posttest scores of students in solving Boyle's and Charles' Gas Laws Problem.

Research Questions

1. What is the mean pretest and posttest scores of the participants in each of the control and experimental groups before and after the use of Game of cards (GoC)?

2. Is there a significant difference in the mean pretest and posttest score of each of the two groups?

3. What is the effect size of the Game of Cards (GoC) strategy on students' problem-solving performance in Boyle's and Charles' Gas Laws?

Definition of Terms

Card Games - a set of small, rectangular pieces of stiff paper with a number and one of four signs printed on them, or a similar set of cards, are used to play the game of cards, which has a specific name and set of rules.

Problem Solving - the process of resolving challenging or complex problems.

Intervention - a deliberate and planned activity that a person or organization takes to solve a specific circumstance, issue, or difficulty.

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Physics - a natural science studies matter, energy, and how matter interacts with itself. It also covers all of a system's physical manifestations and processes.

METHODOLOGY

Research Design

This study employed a quasi-experimental research design to evaluate the effectiveness of Game of Cards (GoC) Strategy in improving students' ability to solve problems related to Boyle's and Charles' Gas Laws. The design involves administering pretests and posttests to different groups of students, one group (section B) is controlled and the other group (section A) applies the GoC Strategy. This approach enables the evaluation if there is significance in the implementation of GoC strategy to the experimental group.

Research Environment

The research was carried out at Caragasan National High School, Caragasan, Alfonso Lista, Ifugao.

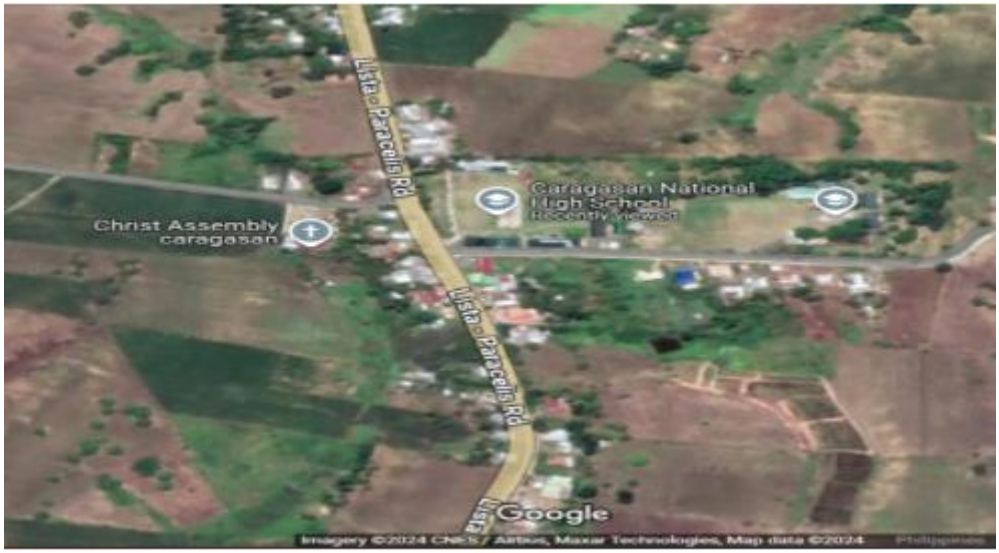

Figure 3: Google Map of Caragasan National High School

Research Participants

The study includes a total of 60 respondents from two sections of Grade 10 learners. Section Alpha comprises 30 students participating in the experimental group, while Section Bravo also has 30 students serving as the control group for the school year 2024-2025.

Research Instrument

The researchers employed purposive sampling to select 60 learners for the experimental and control groups in this study. The research procedures involved administering a standardized pretest at the beginning of the lesson, lasting for 15 minutes, to both sections. Additionally, students' insights were also collated before the pretest was conducted.

The participants investigated the relationships between the following:

1. Volume and pressure at a constant temperature of a gas.
2. Volume and temperature at a constant pressure.
3. Explaining these relationships using the Kinetic Molecular Theory.

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For the experimental group, the researchers used the Game of Cards (GoC) to solve problems in Boyle's and Charles' Gas Laws, identified as least mastered skills in Physical Science 10. The GoC included corresponding activities such as guide cards, activity cards, and assessment cards.

The following are the steps of the Game of Cards:

Step 1: Guide card

This consists of key words associated with Boyle's and Charles' Gas Laws, properties of gases, definition, units, formulas and 2 examples of problem solving of each gas law. These cards were distributed to the participants and the researchers explained the following terms and definitions for 15 minutes.

Step 2: Activity card

It consists of 2 problems solving for Boyle's and Charles Gas Law. These cards were given to the participants and the researchers let the students answer the following problems for 20 minutes.

Step 3: Assessment card

In this activity it consists of key words and statements to let the students master the following terms and definitions regarding Boyle's and Charles` Gas Laws for 10 minutes.

The Game of Cards (GoC), used as Strategic Intervention Materials (SIM) to help learners improve their skills in solving Boyle's and Charles' Gas Laws in Physical Science 10, which they struggled with during regular classes. An actual photo of the Intervention Materials can be found in Appendix A.

The activities allocated a 30-minute response time, followed by a 10-minute posttest for Grade 10 students. In contrast, the control group had a 30-minute lesson discussion before taking the 10-minute posttest.

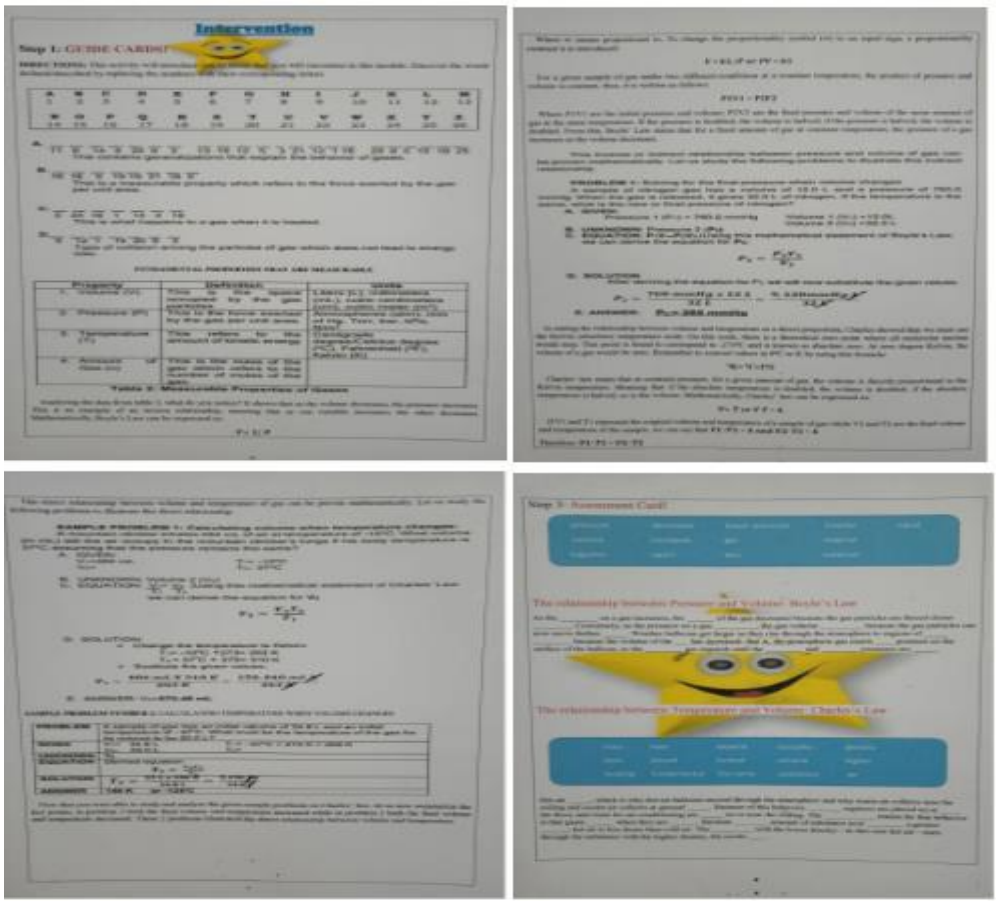

Figure 4: The Game of Cards (GoC)

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Data Collection and Analysis

To evaluate the efficacy of the Game of Cards, a research design was implemented to compare pretest and posttest results of students before and after participating in the game. The study utilized pretest and posttest data to measure students' scores.

Data analysis was conducted using the mean to determine the pretest and posttest scores of participants in both the control and experimental groups, before and after using the Game of Cards (GoC). A paired sample t-test was utilized to ascertain if there is a significant difference in the mean pretest and posttest scores of the two groups. Additionally, Eta squared was employed to measure the effect size of the study.

Ethical Consideration

The researchers examine whether the study practices are likely to inflict any materials or emotional harm building the data collection approaches. Harm may be caused by:

1. Failing to respect/observe certain cultural values or tradition by the participants.
2. Permission from parents, students, teachers, principal, etc.
3. DepEd Order no. 51, s, 2014 Guidelines on the conduct of activities and use of materials involving aspects of indigenous people culture.
4. Republic Act No. 10533 An Act Enhancing the Philippine Basic Education System By Strengthening Its Curriculum and Increasing the Number of Years for Basic Education, Appropriating Funds Therefore and for Other Purposes.

RESULTS AND DISCUSSION

The data presented in this part follows the arrangement of the problems as set in the Research Questions. Upon the administration and after the conduct of the examination, the collected data and the result of the pre-test and post-test were evaluated and analyzed.

Table 1: The mean pretest scores of the participants in each of the control and experimental groups before the use of Game of cards (GoC).

Group Statistics

Group		N	Mean	Std. Deviation
Pretest	Experimental	30	6.13	2.315
	Control	30	4.30	1.442
Posttest	Experimental	30	14.43	1.006
	Control	30	6.33	1.493

The paired sample statistics shows the mean score for the pretest before the Game of Cards intervention was 6.13, while the mean score for the posttest after the intervention increased to 14.43. This indicates an average improvement of 8.3 points from pretest to posttest, suggesting that the intervention had an effect on the student's performance in problem-solving regarding Boyle's and Charles' Gas Laws.

Based on the pretest scores of the participants, the results revealed that the experimental groups differ from the control group just a few points. This means that the participants had less knowledge about the topic. During the posttest, the scores of the participants increased. The experimental group differs from the control group. The results suggest that using the intervention has an effect on the performance of the students.

To align with the results, Game-based interventions have been shown to enhance student engagement and academic achievement (Yilmaz & Yilmaz, 2021). The notion that games and technology can greatly improve

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educational experiences is supported by Chiotaki et al. (2023), who found that adaptive game-based learning improves student engagement and learning results.

Table 2: A significant difference in the mean pretest and posttest score of each of the two groups

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest Experimental	6.13	30	2.315	.423
	Posttest Experimental	14.43	30	1.006	.184
Pair 2	Pretest Control	4.30	30	1.442	.263
	Posttest Control	6.33	30	1.493	.273

The table presents the results of paired sample statistics comparing the pretest and posttest scores between an experimental group and a control group. The Pretest of both groups had a t-value of 3.681 with a p-value of < 0.05, indicating that there is a significant difference. The Posttest had a t-value of 24.638 with a p-value of <0.05, tells us that we reject the null hypothesis, therefore there is a highly significant difference between the two groups using the 95% confidence interval.

The pretest had a standard deviation of 2.315, indicating moderate variability in student scores before the intervention. The posttest had a standard deviation of 1.006, suggesting that after the intervention, students' scores became more consistent. The pretest standard error mean is 0.423, and the posttest standard error mean is 0.184, showing that the estimate of the population mean is more precise for the posttest. Align with the study of Yilmaz and Yilmaz (2021) that game-based learning can reliably improve students' reasoning and problem-solving abilities.

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Pretest & Posttest Experimental	30	.330	.075
Pair 2	Pretest & Posttest Control	30	.416	.022

The table presents the correlation coefficient with 0.330 which is relatively weak, indicating a weak positive relationship between the pretest and posttest scores. This suggests that while some improvement is expected, it is not entirely predictable based on pretest performance alone. The p-value is <0.075 which is slightly above the common significance threshold of <0.05, indicating that the correlation is not statistically significant. This weak correlation suggests that the changes in scores are not just the result of an inherent relationship between pretest and posttest performance, but likely due to the intervention. Even in cases when initial performance measures do not substantially predict post-intervention results, focused interventions can have a considerable impact on learning outcomes, according to a systematic literature review by Anderson et al. (2021).

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Low	Upp			

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					er	er			
Pair 1	Pretest - Posttest Experimental	-8.300	2.200	.402	-9.121	-7.479	-20.668	29	.000
Pair 2	Pretest - Posttest Control	-2.033	1.586	.290	-2.626	-1.441	-7.021	29	.000

The table illustrates the mean differences of the pretest which has -8.300, SD is 2.200 and Standard error mean is 0.402. The mean difference of -8.300 shows a significant improvement in student performance from pretest to posttest. The standard deviation of 2.200 and standard error mean of 0.402 tell us about the variation in differences between the pretest and posttest scores across students. The paired sample t test yielded a t-value of -20.668 which is extremely large in magnitude, indicating a very strong effect of the intervention. The p-value of <0.05 from the paired samples test strongly indicates that the improvement in students' performance from pretest to posttest is statistically significant, meaning that the observed change is not due to random chance. The results overview that 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).

According to the study of Deta et al. (2021) based on educational physics games, especially "board games and cards" has a high level of effectiveness based on increasing student learning outcomes. Another study comes from Mendo-Lázaro et al. (2022) research supports the premise that educational games can have a considerable impact on learning outcomes, hence supporting the usefulness of GoC strategy interventions in the improvements of student's performance.

Table 3: The effect size of the Game of Cards (GoC) strategy on students' problem-solving performance in Boyle's and Charles' Gas Laws

Report

Posttest Experimental

INTERVENTION	Mean	N	Std. Deviation	Median
1	14.68	22	.477	15.00
2	13.75	8	1.669	14.00
Total	14.43	30	1.006	15.00

The data presented for all 30 students (combining both intervention groups), the mean posttest score is 14.43 with a standard deviation of 1.006, indicating moderate variability. The median score of 15.00 suggests that most students scored around 15, showing a relatively central tendency towards higher scores.

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
Posttest Experimental *	Between	(Combined)	5.094	1	5.094	5.876	.022

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INTERVENTION	Groups					
	Within Groups	24.273	28	.867		
	Total	29.367	29			

The ANOVA table tests show the significant differences in posttest scores based on the type of intervention. The f-value is 5.876 and the p-value of 0.022 indicate that there is a statistically significant difference between the two intervention groups in terms of their posttest scores. Since the p-value is less than 0.05, we can conclude that the differences in mean posttest scores between Group 1 and Group 2 are statistically significant. While, within groups the Sum of Squares is 24.273, df = 28, Mean Square is 0.867. This value shows the variance within each group. The mean square of 0.867 represents the average variability within groups. The total Sum of Squares is 29.367 and df = 29. This is the total variance in the posttest scores across all groups.

Measures of Association		
	Eta	Eta Squared
Posttest Experimental * Intervention	.416	.173

Table 5 shows the effect size of the Game of Cards (GoC) strategy on students' problem-solving performance in Boyle's and Charles' Gas Laws. The eta value of 0.416 indicates a medium to large effect size. This means that approximately 41.6% of the variability in students' posttest scores can be explained by the intervention (GoC strategy). This suggests that the intervention had a moderate to strong impact on students' problem-solving performance. While the Eta squared is the proportion of variance explained by the independent variable. An eta squared of 0.173 means that about 17.3% of the total variation in students' posttest scores can be attributed to the type of intervention they received. This confirms that the intervention (GoC strategy) had a large effect on student performance.

To align with the results, according to the study of Levy et al. (2024) gamification has attracted considerable controversy' despite the positive effects on student learning outcomes found in a meta-analysis of gamification in educational contexts. Teachers often remain concerned that playing games is merely fun. Therefore, it is necessary to integrate applicable guides into the design of game-based learning according to students' perspectives for providing engaging learning experience (Zeng et al., 2020).

According to the study of Van der Linden and Van Joolingen (2019) In a quasi-experimental evaluation between a game group and a traditional group (receiving no game) with 73 participants no significant gain in knowledge was measured in either group. However, students who played the game were more motivated than students who experienced the traditional lesson. Likewise, according to Cardinot and Fairfield (2022), participants also felt that the educational game contributed to enhancing motivation and engagement with Physics, but embracing games for physics education is still a challenge for some teachers.

CONCLUSION AND RECOMMENDATION

The following are the main conclusions and recommendations drawn from the study's finding:

Conclusions

The following are the main conclusions drawn from the study's finding:

1. The experimental group significantly outperformed the control group in the posttest, demonstrating that the experimental intervention or treatment had a strong positive effect.

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2. The data shows that the Game of Cards (GoC) strategy intervention significantly improved the problem-solving skills of Grade 10 students in relation to Boyle's and Charles' Gas Laws. The large improvement in posttest scores and the statistical significance of the results provide strong evidence for the effectiveness of the (GoC) strategy.
3. Therefore, using the Game of cards (GoC) has a significant effect on their academic performance. The difference between the two groups is very evident. As a result, using the GoC can enhance students' abilities in solving Boyle's and Charles' Gas Laws.

Recommendations

1. Given the strong positive outcome in the experimental group, replicating this intervention in other settings could validate its effectiveness further. However, the control group showed minimal improvement, suggesting that alternative methods or interventions may be necessary for them. This could lead to a more equitable learning or development experience for all participants.
2. Since the intervention led to significant improvement in student performance, it is recommended that the Game of Cards (GoC) strategy be incorporated into regular teaching for better engagement and understanding of scientific concepts. Teachers may also consider adapting the strategy for other topics to see if similar improvements can be achieved. Future studies could examine the long-term retention of the skills learned through the (GoC) strategy. It would be valuable to investigate whether students retain their problem-solving abilities over time after the intervention.
2. The significant effect of the GoC strategy, as indicated by the effect size, suggests that this teaching method should be considered for wider adoption in classrooms teaching Boyle's and Charles' Gas Laws. Further refinement and scaling up of the strategy could make it even more effective for diverse student populations.

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Appendix A. Pretest and Posttest

NAME: _____ (Optional) GRADE/YEAR: _____ DATE: _____

DIRECTIONS: Read each question below and choose the letter that best answers the question or completes the statement. Write the letter of your answer in your answer sheet. USE CAPITAL LETTER.

1. Gases are compressible and expandable depending on the pressure applied. These observed properties of gases are due to _____.

A. lesser density

B. wide spaces between gas particles

C. uniform pressure exerted

D. undefined shape and size

2. Complete the analogy: _____: mm of Hg, atm; Volume: mL, L

A. Temperature B. Moles

C. Pressure D. water

3. When you open a bottle of soda pop, carbon dioxide gas seems to escape from the liquid. What gas law does this illustrate?

A. Boyle's Law B. Charles' Law

C. KMT D. A & C 3

4. A device called an iron lung was used frequently at one time to help children who were afflicted with polio. The iron lung was used to help the patient breathe. What gas law explains the principle behind the functioning of the iron lung? (Choose the letter of your answer from number 3)

5. He is known for his experiment on the relationship between pressure and volume at constant temperature.

A. Jean Jacques Charles B. Richard William Boyle

C. Robert William Boyle D. Jacques Jean Charles

Read and analyze the problem below to be able to answer questions 6-9.

The volume of a gas is 10L when its pressure is 1 atm. How much pressure must be applied to reduce its volume to 5 mL at constant temperature?

6. Based on the given data, what is the unknown in the problem presented?

A. V1 B. V2

C. P1 D. P2

7. What measurable properties are given in the problem?

I. P1

II. P2

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III. V1

IV. V2

A. I only B. II only C. I, III & IV D. I, II & III

8. Which describes what happened to the volume of gas?

A. It increased from 5 L to 10 L

B. It decreased from 10 L to 5L

C. It remained the same

D. Nothing happened

9. What is expected to happen with the final pressure (P2) of the gas?

A. It will increase. B. It will decrease

C. Remains the same D. None

Complete the analogy for numbers 10-12 10.

10. Boyle's Law: Volume-Pressure Relationship; Charles' Law: ____Relationship

A. Temperature-Pressure B. Pressure-Volume

C. Volume Temperature D. No. Moles-Pressure

11. Volume-Pressure Relationship: _____; Volume-Temperature Relationship: Directly Proportional

A. Indirectly Proportional B. Inversely Proportional

C. Both A & B are correct D. B only

The volume of a gas is 10L when its pressure is 1 atm. How much pressure must be applied to reduce its volume to 5 mL at constant temperature?

12.Boyle's Law: Amount of Gas & Temperature; Charles' Law: _____

A. Volume B. Pressure

C. Amount of Gas & Volume D. Amount of Gas & Pressure

13. Read and analyze each statement. Identify the statements which are TRUE?

I. Elastic collision of gas particles means energy is wasted.

II. Boyle's Law shows the inverse relationship between volume and pressure.

III. Charles' Law shows the direct relationship between temperature and volume.

IV. The kinetic molecular theory explains the behavior of gases. A. I only B. II, III and IV C. II and III D. IV only

14. In order to solve gas calculations, temperature must be measured in __

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A. Fahrenheit B. Celsius

C. Kelvin D. any can be used

15. As the temperature _____, the gas particles move faster. What word will correctly complete the statement?

A. decreases B. increases

C. remains the same D. cools