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Effectiveness of Game-Based Lessons in Improving the Performance of Grade 8 Students in Chemistry

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Abstract— This study determined the effectiveness of game-based lessons in Chemistry to improve the academic performance of Grade 8 students at Buhang National High School, Division of Sorsogon Province for the academic year 2022-2023. The study utilized the developmental method of research and involved 30 Grade 8 Einstein students who were randomly selected, and 5 science teachers as evaluators who were purposively selected. The study intended to answer three research questions: (1) What game-based lessons may be developed along specific topics in Chemistry? (2) What is the validity of the developed game-based lessons based on DepEd LRMDS in terms of content, format, mechanics, and accuracy? (3) How effective is game-based learning in improving the academic performance of students in Chemistry? The statistical tools employed in the study included the calculation of weighted means, frequency distributions, and the use of t-tests for dependent samples to analyze the data.

The findings revealed that six game-based lessons in Chemistry were developed using the 7E's model, which are (1) Particle Nature of Matter, (2) Properties of Matter, (3) Phase Changes in Matter, (4) Structure of Atom (5) Atomic Symbols, and (6) Trends in the Periodic Table. The game-based lessons were found to be valid based on DepEd LRMDS, specifically in terms of content, format, mechanics, and accuracy. Furthermore, the developed game-based lessons were found to significantly enhance the academic performance of students, as reflected by their post-test scores.

The study recommended that science educators should further improve the developed game-based lessons by incorporating a variety of game elements and integrating localized and contextualized game materials, in order to enhance students' engagement and learning outcomes. Moreover, the games used in every classroom setting can be modified constantly to meet the needs of different learners and develop the desired competencies. Science educators are encouraged to utilize game-based learning as a means to enhance their students' academic performance and attain higher levels of achievement.

Keywords— effectiveness, game-based lessons, performance level.

INTRODUCTION

In today's ever-evolving world, the role of a teacher is essential. Teachers are tasked with equipping students with the complex skills and knowledge necessary for success in the 21st century, such as critical thinking, problem-solving, and digital literacy. Moreover, teachers must be committed to continuous learning and improvement, constantly seeking out new strategies, techniques, and best practices to enhance their ability to meet the diverse needs of their students. By embracing this ongoing process of growth and development, teachers can ensure that they are providing the highest quality education possible.

The education system in the Philippines faces a multitude of challenges, with one of the most pressing being the issue of underachievement among Filipino students. In international evaluations such as the 2019 Trends in International Mathematics and Science Study (TIMSS) and the 2018 Program for International Student Assessment (PISA), Filipino students consistently rank among the lowest in the world. For instance, in the 2019 TIMSS assessment, the Philippines ranked 50th out of 58 countries at the Grade 4 level in Science and 53rd out of 58 countries at the Grade 8 level in Science (Mullis, 2020). Similarly, in the 2018 PISA assessment, only 13% of Filipino students reached the "low benchmark" for scientific understanding, with the remaining students falling below this level. This places the Philippines second to last in rank in science with 357 points, well below the global average of 489 points (Tadalan, 2021).

To meet the challenges of providing quality education, teachers can attend seminars, trainings, and workshops, which can provide them with invaluable opportunities to stay abreast of the latest research and trends in education, while also connecting them with other educators. However, being an effective teacher requires more than just acquiring new knowledge and skills. It also demands high levels of flexibility, creativity, and adaptability. With evolving situations, it has been

proven that teaching using fun-based approaches results in lasting learning among learners. Hence, the Department of Education (DepEd) in partnership with Microsoft Philippines, has rolled out its game-based learning program, The Minecraft Education Edition, to incorporate digital games into lessons (Labesig, 2022).

Game-based learning, as defined by Li (2018) is a type of instructional approach that uses games or game-like activities as a means of motivating and engaging learners, while promoting learning outcomes. According to Aldrich (2014), it refers to any situation in which the learning process is embedded within an experience that has game-like characteristics. Meanwhile, Taylor (2014) defines it as a mode of teaching and learning that utilizes game design, mechanics, and content to engage students in deep learning experiences. By using game-based lessons, teachers can create a more dynamic and engaging learning environment that promotes active learning and higher student engagement.

The primary purpose of game-based learning (GBL) is to motivate and engage learners. Engagement and motivation are essential components of student success and learning. When students are engaged in their studies, they actively participate in the learning process. They become curious and interested in the subject matter, and are more likely to ask questions, seek out information, and participate in classroom discussions. By using GBL, teachers can create a more dynamic and interactive learning environment that encourages students to take an active role in their education. As a result, GBL has become increasingly popular as an effective instructional tool in education, particularly in subjects that are traditionally difficult or challenging for students.

Numerous studies have shown that digital games and traditional, “low tech” game-based learning can have a positive effect in the classroom, as it is an effective tool for increasing student motivation and engagement. In a critical review about digital game-based learning, Huang, Liang, & Chou (2017) found out that digital GBL had a positive effect on students' learning outcomes in STEM subjects. The study found that digital games were particularly effective in improving students' knowledge acquisition and retention. In another study of Satrio, (2021), digital online competitive game, e-Crowdwar was found effective in enhancing students’ interests and performance in high school economics. Digital games also proved to be effective in enhancing students’ understanding and learning of difficult subject such as Trigonometry (Jorda & Santos, 2015).

Despite the popularity of digital games, low tech games are still considered an effective instructional tool as they utilized locally available materials and resources. They can be used even without internet connection or electric power. They can also be easily modified to fit any learning objective and can be played inside or outside the classroom.

For example, Bagadiong (2013) conducted a study on the use of low-tech games to teach quadratic function to Grade 10 students and found that games such as "Go on a Hunt" and "QF Snakes and Ladders" were effective tools in enhancing students' performance in Mathematics. Similarly, Tabago (2014) developed Pinoy game-based activities using quasi-experimental design and found that these activities were effective in concretizing physics concepts, such as work, power, and energy. In addition, Furio (2022) conducted a study on using games as remedial instruction for low-performing and high-performing students in Rational Algebraic Expression and found that it was effective in enhancing the performance of both groups and resolving the achievement gap. These studies highlight the potential of low tech games in enhancing students' learning outcomes and academic performance.

The importance of creating an interactive classroom environment cannot be overstated as it can greatly enhance the learning experience of students. In traditional methods of teaching, students' attention can often be limited, and they may feel disengaged and uninterested.

This can result in feelings of inattentiveness and drowsiness, ultimately hindering their ability to absorb and retain information effectively. On the other hand, an interactive classroom provides students with opportunities to engage in discussions, ask questions, and collaborate with peers. As a result, students are more likely to stay focused, motivated, and actively participate in the learning process.

The study aimed to determine the effectiveness of game-based lesson in the performance of grade 8 students in chemistry in Buhang National High School, Province of Sorsogon, Philippines.

II. METHODOLOGY

This study employed a descriptive-developmental method as it aimed to determine the following: (a) the level of performance of students in the pretest and posttest results, (b) the experts' validity of the game-based lessons using DepEd LRDMS criteria, and (c) the difference between the pretest and posttest scores before and after the utilization of the game-based lessons. The study also utilized a single-group, pretest-posttest design to assess the effectiveness of game-based lessons as an intervention.

The respondents consisted of thirty (30) Grade 8 students from Buhang National High School and five (5) teachers from four schools in the province of Sorsogon. The teachers served as evaluators due to their expertise in the field of chemistry. The instruments used to gather the necessary data were teacher-made tests and expert validation sheets. Additionally, several statistical tools, such as frequency count, percentage and mean, and t-test for dependent data, were utilized.

The researcher employed a 50-item teacher-made test, specifically designed to assess the four (4) most essential learning competencies for the third quarter of Grade 8 Science based on the K to 12 Basic Education Curriculum. To ensure the test's alignment with the learning competencies, an Expert Assessment Sheet (EAS) was utilized to review the coherence of the test items. Furthermore, a dry run was conducted, followed by an item analysis to evaluate the effectiveness of the test items.

In order to determine the internal consistency of the test, a reliability test was performed. After validating the final test questions, the same test was administered to Grade 9 Socrates students in the same school. The selection of respondents was carried out with utmost care, involving the acquisition of permission from the superintendent, school head, and subject teachers. The researcher determined the topic or lesson to be presented which are particle nature of matter, properties of matter, phase changes in matter, structure of atom, atomic symbols and trends in the periodic table. Then the researcher used simple random sampling in selecting the students - respondents while the purposive sampling used to determine the experts - respondents of the study.

The researcher sought the expertise of teachers in the field to validate the game-based lesson plans (GBLPs). To facilitate this process, the Expert Validation Sheet (EVS) was employed, which was adapted from the criteria used by DepEd LRMDS (Learning Resource Management and Development System). The expert's carefully reviewed the GBLPs, assessing them based on four key indicators: (1) content, (2) format, (3) mechanics, and (4) accuracy. Their valuable feedback, comments, and suggestions were taken into account for further refinement and enhancement of the GBLPs.

Subsequently, the developed GBLPs underwent thorough testing and validation. The final validation process was carried out by the experts, who conducted a comprehensive assessment to ensure the quality and effectiveness of the GBLPs. The researcher carefully considered and incorporated the suggestions and comments provided by the experts, utilizing them to revise and improve the GBLPs, thus ensuring their utmost quality and alignment with educational standards.

To ensure ethical considerations and cooperation of the respondents, the researcher took several steps. Firstly, permission was sought from the Superintendent of Schools Division of Sorsogon. Following the approval obtained, formal permission was then sought from the school head of Buhang National High School to conduct the study within the school premises. Once the principal granted approval, the researcher proceeded with conducting the pretest on February 13, 2023. The respondents were provided with clear and concise instructions on how to answer the 25-item test and were given a dedicated time frame of one hour to complete it. During this process, the researcher diligently collected both the test papers and answer sheets, achieving a commendable retrieval rate of 100%. The results were carefully checked, recorded, and made available for statistical interpretation.

The game-based lessons developed by the researcher were carefully designed to align with the most essential learning competencies for the 3rd quarter of Chemistry 8. In total, six (6) game-based lesson plans (GBLPs) were created, ensuring a well-rounded coverage of the targeted competencies. To validate the effectiveness and quality of these GBLPs, the researcher personally distributed the Experts Validation Sheets (EVS) to the identified experts-respondents, achieving a retrieval rate of 100%.

The intended duration for the implementation of the game-based lessons was set at three weeks, allowing

ample time for students to fully engage with and grasp the content. Each game-based lesson was designed to span approximately 2-3 days, ensuring sufficient coverage of the material while keeping students actively involved and motivated.

Following the utilization of the game-based lessons, a posttest was administered to measure the difference in the students' performance. This assessment served as a valuable tool for evaluating the impact and effectiveness of the game-based lessons on the students' learning outcomes. The posttest aimed to assess the progress made by the students after being exposed to the engaging and interactive GBL, providing valuable insights into the effectiveness of this instructional approach.

To assess the effectiveness of the game-based lessons in improving the performance of Grade 8 students in Chemistry, the gathered data underwent various statistical analyses and interpretations.

The data were analyzed and interpreted using statistical techniques such as frequency count, percentage, mean, and t-test.

The level of performance of the respondents were analyzed and interpreted using the scale based on DepEd Order No. 8, s. 2015.

Furthermore, the weighted mean was utilized to describe the validity of the developed game-based lessons. Additionally, a t-test for dependent samples was employed to determine the significant difference in the students' performance between the pretest and posttest.

III. RESULTS AND DISCUSSIONS

The presentation and analysis of the data are the following:

1. Performance level of the students in the pre-test and post-test along particle nature of matter, properties of matter, phase changes in matter, atomic structure, atomic symbols and trends in the periodic table.
2. Developed games along the identified topics.
3. Validity of the developed game-based lessons based on DepED LRDMS along content, format, mechanics and accuracy;
4. Difference between the level of performance of the respondents along the identified topics in the pre-test and post-test.

1. Performance level of the Students in the Pre-test and Post-test

Table 1A displays the results of the pre-test and post-test scores per topic administered to grade 8 Einstein students. The mean scores for each test indicate that the students' performance improved by the end of the study. Notably, the utilization of the developed learning materials resulted in a very satisfactory mean score, highlighting the effectiveness of the materials.

Based on the mean percentage scores, the students' pre-test scores were generally lower (56) compared to their post-test scores (86). This may indicate a significant conceptual change in the students before and after utilizing the game-based lessons.

Table 1A: *Performance level of the Students in the Pretest and Post-test Scores along the six topics*

Topics	Pretest MPL (%)	Description	Posttest MPL (%)	Description
1. Particle Nature of Matter	70	Did not meet the expectation	88	Very Satisfactory
2. Properties of Matter	57	Did not meet the expectation	84	Very Satisfactory
3. Phase Changes in Matter	56	Did not meet the expectation	88	Very Satisfactory
4. Structure of atom, ion and isotope	56	Did not meet the expectation	83	Satisfactory
5. Atomic symbols	48	Did not meet the expectation	88	Very Satisfactory
6. Trends in the Periodic table	51	Did not meet the expectation	87	Very Satisfactory
Over-all	56%	Did not meet expectation	86%	Very Satisfactory

2. Developed game-based lessons in Chemistry 8 along the identified topics

The developed game-based lesson utilized the 7E's (Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend) fused with game elements in Exploration and Elaboration part. Ideally, 2-3 hours are given to finish each lesson. The teacher designed each GBL based on the most essential learning competencies in the 3rd Quarter of Science 8. The GBLPs were modified to suit the teacher's capacity and the learners' needs. The topics included were Particle Nature of Matter, Properties of Matter, Phase Changes in Matter, Structure of Atom, Atomic Symbols and Trends in the Periodic table.

Developed Game on Particle Nature of Matter

Game number 1 is entitled "Particle Challenge: Build, Classify and Master Matter". This game is utilized in the exploration part of the lesson to acquaint learners with

what matter is made of. Due to its abstract nature, this competency is considered a critical topic in chemistry, as it forms the foundation of understanding of many chemical phenomena and concepts (Aguirre-Mendez, 2018). In addition, this competency is also a pre-requisite for the understanding of the subsequent topics. After playing the game, it is expected that students will be able to illustrate the particles of solids, liquids, and gases, and demonstrate their understanding of the particles of water during the process of evaporation, condensation and precipitation.

Developed Game on Properties of Matter

The game entitled "Family Matters" was utilized during the exploration part of the lesson. Inspired by the popular game show Family Feud, this game served as a continuation of the knowledge acquisition process introduced in the first game.

The "Family Matters" game is an engaging and fun challenge that aims to enhance students' understanding of the fundamental concepts underlying the properties of solids, liquids, and gases. The game is designed based on the Flow Theory, proposed by Csikszentmihalyi. It suggests that learning is more effective when learners are in a state of flow, characterized by intense focus and enjoyment. Games can create a state of flow by providing learners with challenging tasks and immediate feedback.

Developed Games on Phase Changes in Matter

The game is entitled, "Charade of Particles". An interactive and engaging tool inspired by the game, Charades. This caters to both the cognitive and psychomotor aspects of its players. It was utilized during the exploration phase to demonstrate the changes occurring in the particles of matter during various phase transitions.

The game is designed based on Situated Learning Theory of Lave and Wenger, which suggests that learning occurs best in real-life contexts. By providing an immersive and interactive environment that mimics real-life situations, game-based learning becomes an ideal tool for teaching critical content and concepts in science. It is expected that after the game, students will be able to describe the particles and molecules of water during different phase changes such as freezing, melting, evaporation, condensation, sublimation and deposition.

Developed Game on Structure of Atom

This game is entitled, "Atomic Architect". The researcher administered this game to help students identify the charges and locations of the three subatomic particles of atom. The game also allowed students to practice solving for the number of protons, electrons and neutrons in neutral atoms, ions, and isotopes.

This game is designed based on Cognitive Load Theory of Sweller, which suggests that learning is more effective when the cognitive load is reduced. Familiarizing the concept of atom, ion and isotope together with the charges and locations of the subatomic particles is quite hard, hence employing games is important. Games can be designed to reduce cognitive load by breaking down complex concepts into smaller, more manageable chunks, as well as provide clear objectives, feedback, and scaffolding, to avoid cognitive overload and facilitate learning.

Developed Games on Atomic Symbols

The name of these games were "Symbol Scrabble" and "Word Quest". Introduced to the learners to help them master the atomic symbols before proceeding to the more complex lessons in chemistry. These games showcased the power of atomic symbols to create words and sentences, which excited the players and made the learning experience more enjoyable.

The game has been designed based on the Self-Determination Theory proposed by Deci and Ryan. This theory suggests that learners are more motivated when they have autonomy, competence, and relatedness. By designing games that provide learners with autonomy through the ability to make choices, competence by providing challenging tasks, and relatedness by allowing collaboration with others, the game becomes an effective tool for teaching critical content and concepts in science. In the game, constructing words and sentences from atomic symbols enables learners to develop the skills provided by the Self-Determination theory. This includes autonomy, as they can choose which symbols to use and how to construct their words and sentences. It also develops competence, as learners are challenged to use their knowledge of atomic symbols to create meaningful words and sentences. Additionally, learners can collaborate with others in the game, providing a sense of relatedness that further enhances their motivation to learn. By incorporating the principles of Self-Determination Theory into game design, learners are more likely to be engaged and motivated to learn.

Playing this game is expected to help students master the atomic symbols and become familiar with the placement of elements in the periodic table. By using atomic symbols to form words and sentences, students can improve their recognition and recall of the symbols. Additionally, the game provides an interactive and engaging way for students to explore the periodic table.

Developed Game on Trends in the Periodic Table

The game, called "The Trend-ing Game", was designed to assist learners in identifying the different trends in the periodic table. This game simplifies the topic by providing visual representations of sample atom sizes, electronegativity, ionization energy, electron affinity and metallic trends. By using this game, learners can easily understand and visualize these complex concepts.

According to Cooper and Klymkowsky (2013), understanding trends in the periodic table can be difficult for several reasons. First, the periodic table is a complex and abstract representation of the elements, and understanding its organization and patterns requires students to think conceptually and understand relationships between elements rather than just memorizing isolated facts.

Second, trends in the periodic table are influenced by multiple factors, including atomic size, electronegativity, ionization energy, and electron affinity. These factors interact with each other in complex ways, and understanding how they affect the properties of elements can be challenging for students.

Third, learning the specialized vocabulary associated with the periodic table, such as atomic radius, ionization energy, and electronegativity, can be a hurdle for students. The terminology can be overwhelming, and students may struggle to grasp the meanings of the various terms.

Finally, visualizing abstract concepts like atomic size and electronegativity can be difficult for students, which can make it challenging for them to understand and apply trends in the periodic table.

To address the difficulties associated with understanding trends in the periodic table, the Trend-ing game is designed based on Dual Coding Theory. This theory suggests that people process information through both visual and verbal channels, and that by representing information in both formats, learners can make connections between different representations and gain a deeper understanding of the information.

In the game, players are given visual card games which engages them in both visual and verbal processing. This approach helps learners to visualize abstract concepts and make connections between different elements and trends in the periodic table. By providing multiple representations of the information, the game facilitates a deeper level of understanding and enhances students' ability to master the complex concepts associated with the trends in the periodic table.

These developed game-based lessons are designed primarily to develop interest and improve students' performance in chemistry. It utilized teacher-made games and games from a source slightly revised by the teacher to harness interest of students in learning Chemistry concepts. Through this, learners could enter a child-friendly and motivating environment in response to DepEd Order N0. 39, s. 2016.

3) Validity of the game-based lessons based on DepEd LRMDS

It is important to measure the validity of GBLP (Game-Based Lesson Plan) before it is widely disseminated to ensure that it is ready for use. In this study, the Expert's Evaluation Checklist was utilized to gather feedback from evaluators on the various aspects of the game-based lessons that were designed. It was scrutinized and rated based on DepEd LRMDS along content, format, mechanics and accuracy. The developed game-based lessons underwent validations from five (5) evaluators

Validity of Game-Based Lesson 1

Table 2A presents the results of the validation process conducted by evaluators to assess the game-based lesson on the particle nature of matter based on specific criteria. The highest-rated criterion for the lesson was accuracy, receiving an overall weighted mean of 3.98. This indicates that the game-based lesson on particle nature of matter was free of errors such as conceptual, factual, grammatical, computational, and obsolete information. The second-highest rated criterion was content, with an overall weighted mean of 3.92, indicating that games 1 and 2 was suitable for the students' level of cognition and skills. The format received a slightly lower rating of 3.87, suggesting that the material has minor problem on illustrations and texts. Mechanics received the lowest rating of 3.83, indicating that revisions may be necessary to improve the logical flow of ideas, varied

sentence structures, and adapted vocabulary to the target reader's level of understanding.

Overall, the game-based lesson on the particle nature of matter was validated as an effective teaching tool by the evaluators, achieving its intended objectives and promoting desirable values and traits among students.

Table 2A: *Validity of Game-based Lesson on Particle Nature of Matter*

Criteria	Average Weighted Mean	Interpretation
Content	3.92	VS
Format	3.87	VS
Mechanics	3.83	VS
Accuracy	3.97	VS

Legend: VS – Very Satisfactory

Validity of Game-Based Lesson 2

Table 2B displays the outcomes of an assessment conducted on a game-based lesson on the Properties of Matter. The evaluation revealed that both Content and Accuracy achieved the highest rating of 3.94, signifying that the activities provided, such as “Bring me”, “Ice cold soda set-up, and the game “Family matters” was appropriate for the development of higher cognitive skills such as critical thinking, learning by doing and inquiry. The lesson's Format was evaluated at 3.90, indicating that the game activity sheet had shortage design and lay out to make it attractive and pleasing to look by the players. In contrast, Mechanics received the lowest score among the four criteria evaluated, as the material lacked crucial details concerning game mechanics, specifically the absence of rubrics for scoring individuals who do not win but attempt to complete the game. Thus, it was recommended to modify the scoring system of the game to address this gap.

Furthermore, the evaluators recommended adjusting the games to be placed in the exploration section of the lesson plan rather than in the explanation part. This modification is necessary to establish a logical and smooth flow of ideas that is appropriate for the intended audience's level of understanding. By implementing these changes, the presentation would become more engaging, interesting, and comprehensible to the learners. Overall, the assessment results indicate that the game-based lesson on the Properties of Matter is a valid and effective teaching strategy that achieves the desired objectives. The evaluations provided by the experts demonstrate that the lesson plan promotes a deeper understanding of the subject matter. The modifications recommended by the evaluators highlight the potential of game-based learning as a tool for enhancing learners' motivation and engagement with complex scientific concepts.

Table 2B: *Validity of Game-Based lesson on Properties of Matter*

Criteria	Average Weighted Mean	Interpretation
Content	3.94	VS
Format	3.90	VS
Mechanics	3.84	VS
Accuracy	3.94	VS

Legend: VS – Very Satisfactory

Validity of Game-Based Lesson 3

Table 2C presents the evaluation results of a game-based lesson focused on Phase Changes in Matter. The accuracy criterion received the highest rating of 3.95 indicating that the material provided precise information, free from conceptual, factual and grammatical errors.

The assessment results indicate that the Content of the Properties of Matter lesson plan received a very satisfactory rating of 3.93, highlighting the effectiveness of the engage activities that incorporate happy and sad emojis in capturing students' attention and interest. This approach is aligned with the principles of game-based learning, which emphasize the importance of creating an immersive and enjoyable learning environment to promote active engagement and motivation among learners.

The "Charade of Particles" game, which is utilized in the exploration phase of the lesson plan, is an excellent example of how game-based learning can be leveraged to promote teamwork and cooperation while reinforcing values and traits that are uniquely Filipino.

This approach ensures that students not only learn the properties of matter but also develop important social skills and cultural awareness, leading to a well-rounded and holistic learning experience.

The ratings for format and mechanics were 3.88 and 3.86, respectively, indicating that these two criteria require further improvement to effectively achieve the lesson's objectives.

Overall, the evaluation results suggest that the game-based lesson on Phase Changes in Matter was effective and could be used to enhance learning outcomes in this area.

Table 2C: *Validity of Game-Based Lesson on Properties of Matter*

Criteria	Average Weighted Mean	Interpretation
Content	3.93	VS
Format	3.88	VS
Mechanics	3.86	VS
Accuracy	3.95	VS

Legend: VS – Very Satisfactory

Validity of Game-Based Lesson 4

Table 2D presents the evaluation ratings for an atomic structure lesson. The highest rating was received by the accuracy criterion with a score of 3.98, emphasizing that the lesson is accurate since it is conceptual, factual, grammatical error free.

It was closely followed by content with a rating of 3.96, demonstrating the effectiveness of the activities presented in the lesson. The engage activity, 4-PICS 1-word, successfully captured the learners' interest in the elicitation phase, stimulating their curiosity and encouraging active participation. The Bohr's model activity in the engage phase and the exploration activity that focused on learning different energy levels also proved effective in promoting active engagement and a deeper understanding of the subject matter.

Furthermore, the assessment results suggest that the game-based activities in the elaboration phase were particularly effective in transferring the concepts learned in the previous parts of the lesson. These activities provide students with an opportunity to apply their knowledge in locating and solving the numbers of subatomic particles: protons, electrons and neutrons.

The mechanics criterion received a rating of 3.90, indicating that some improvements are needed to establish a more coherent and logical flow of ideas.

The Format received a rating of 3.89, suggesting that improvements are needed in its size, spacing, labeling, fonts, and illustrations. To improve the overall readability and presentation of the lesson plan, adjustments can be made to the size and spacing of the text to enhance readability and make it easier to navigate. Utilizing clear and concise labeling, appropriate fonts, and relevant illustrations can also enhance the lesson plan's overall format and make it more visually appealing to students.

Overall, the evaluation results suggest that the atomic structure lesson was effective and valid, with only minor suggestions for improvement in mechanics and format.

Table 2D: *Validity of Game-Based Lesson on Structure of Atom*

Criteria	Average Weighted Mean	Interpretation
Content	3.96	VS
Format	3.89	VS
Mechanics	3.90	VS
Accuracy	3.98	VS

Legend: VS – Very Satisfactory

Validity of Game-Based Lesson 5

Based on the data presented in Table 2E, it can be observed that the atomic symbols game-based lesson received favorable ratings from the evaluators. The accuracy criterion received the highest score of 3.98, indicating that the game was free from errors and provided correct and reliable information.

The high score of 3.92 received by the content criterion is also a proof to the relevance and effectiveness of the activities provided in the lesson atomic symbol. The activities presented from elicit to engage demonstrate a well-structured approach that encourages learners to think critically and make connections to better understand the concept of the periodic table.

The game-based activities presented in the exploration phase, such as "Symbol Scrabble" and "Word Quest," were found to be effective in reinforcing the learners' understanding of atomic symbols. By utilizing these games, learners are encouraged to interact with each other and collaborate in a fun and engaging way while familiarizing and learning the atom.

The mechanics criterion received a score of 3.91, indicates that minor revisions are required to enhance the structure, organization, and coherence of the game for a more logical and smooth flow of ideas. On the other hand, the format criterion received the lowest rating of 3.89, suggesting the need to incorporate illustrations and drawings to improve the game's visual appeal and user-friendliness.

The evaluation of the atomic symbols lesson plan indicated that it has potential to be an effective teaching tool for the students, but further development is necessary to fully realize its benefits. Overall, the feedback received provides valuable insights that can be used to enhance the game and improve its effectiveness in achieving the intended learning outcomes.

Table 2E: *Validity of Game-based lesson on Atomic Symbols*

Criteria	Average Weighted Mean	Interpretation
Content	3.92	VS
Format	3.89	VS
Mechanics	3.91	VS
Accuracy	3.98	VS

Legend: VS – Very Satisfactory

Validity of Game-Based Lesson 6

Based on the results presented in table 2F, the game-based lesson on Trends in the Periodic Table performed well in terms of accuracy with a rating of 3.93, indicating that the lesson presented is free from conceptual and factual errors. The content criterion received a rating of 3.88, demonstrating the material's suitability to the student level of knowledge and contributes to the achievement of specific objectives for which it is intended.

The activities made in elicit, engage and explore part provides for the development of higher cognitive skills like critical thinking, problem solving and inquiry. The activity, "Trending game" also promotes teamwork, unity and cooperation, as they will be playing to achieve the goal of winning.

However, while the game-based lesson on Trends in the Periodic Table was accurate and well-suited to the students' level of knowledge, improvements are needed in the format and mechanics criteria. The low rating of 3.83 suggests that that the design and visual layout of the material require revisions to become more engaging and user-friendly. One way to achieve this is by incorporating a harmonious blend of illustrations and texts, using appropriate colors and labeling or captioning them properly. These enhancements can help clarify the content and make it more attractive and appealing to learners, ultimately leading to a more effective and enjoyable learning experience.

Overall, the game-based lesson on Trends in the Periodic Table shows potential for effective teaching and learning but may require some revisions on format and mechanics to optimize its effectiveness.

Table 2F: *Validity of Game-Based Lesson on Trends in the Periodic Table*

Criteria	Average Weighted Mean	Interpretation
Content	3.88	VS
Format	3.83	VS
Mechanics	3.83	VS
Accuracy	3.93	VS

4. Difference between the Performance of the Students in the Pre-test and Post-test using Game-based Lesson.

Table 3B shows the difference between the pre-test and posttest results of the students along the identified topics. As reflected, the computed t-value is 3.03 which is higher than the critical value of 2.004 at a 0.05 level of significance and 29 degrees of freedom.

Therefore, the null hypothesis is rejected. Hence, there is a significant difference between the pretest and posttest results of the students.

Table 3B: *Difference between the pretest and the posttest results of the students along the identified topics*

Statistical Bases	Particle Nature of Matter	Properties of Matter	Phase Changes in Matter	Structure of Atom	Atomic Symbol	Trends in the Periodic Table
Computed t-value	3.44	6.92	6.71	6.82	9.14	7.39
Decision on Ho	Reject	Reject	Reject	Reject	Reject	Reject
Conclusion	Sig	Sig	Sig	Sig	Sig	Sig

FINDINGS

Based on the analysis and interpretation of data, the following findings were drawn:

1. Six game-based lessons in Chemistry were developed using 7E's model. These are: (1) Particle Nature of Matter, (2) Properties of Matter, (3) Phase

Changes in Matter, (4) Structure of atom, ion and isotope, (5) Atomic symbols, (6) Trends in the Periodic table.

2. The development of game-based lessons aligned with the DepEd LRDMS has been found to be valid in terms of content, format, mechanics, and accuracy. Specifically, the content of the game-based lessons aligns with the learning competencies and objectives of the DepEd curriculum, and is rated as very satisfactory by all evaluators. The format and mechanics of the game-based lessons were also rated as very satisfactory, with some moderate revisions to be made. Additionally, the accuracy of the game-based lessons is also rated very satisfactory.

This means that the posttest result is higher than the pretest result. It implies that the use of the game-based lessons may have improved students' performance.

The table reveals that the students performed differently when exposed to game-based lessons. The post-test scores showed better performance, which may be attributed to the use games. Moreover, the researcher observed a significant increase in teacher-student interaction when employing the game-based lessons. Students showed interest during group activities, and more importantly, they enjoyed learning the topic. The teacher implemented strategies that could enhance the behavior of students during the game, such as focusing on group activities and time management, and adopting meta-cognitive strategies, such as providing feedback, and facilitating group work in class. These strategies were evident in every learning activity, which may have contributed to the improvement of students' performance.

The student respondents demonstrated a significant improvement in their academic performance, as reflected by their post-test scores, which were substantially higher than their pre-test scores, following the implementation of the proposed game-based lessons.

Specifically, the mean of their post-test scores surpassed that of their pre-test scores, indicating a notable increase in their level of proficiency in the subject matter.

These results highlight the effectiveness of the developed learning materials and adapted validation tool in enhancing the students' performance and validating their acquired knowledge.

Moreover, the t computed value of 3.03 is greater than the t critical value of 2.004 at 0.05 level of significance with degrees of freedom of 29. Therefore, the rejection of the null hypothesis which states that there is a significant difference between the pretest and posttest scored of the students.

CONCLUSIONS

Based on findings of the study, the researcher arrived at the following conclusions:

1. The developed game-based lessons in Chemistry were particle nature of matter, properties of matter, phase changes in matter, structure of atom, ion and isotope, atomic symbols and trends in the periodic table utilizing the 7Es towards the attainment of most essential learning competencies.
2. The developed game-based lesson plan passed the validation in terms of the four criteria; content, format, mechanics and accuracy of the information, hence appropriate for use in educational settings.
3. The developed game-based lessons are effective in improving the performance of students in Chemistry along Particle Nature of Matter, Properties of Matter, Phase Changes in Matter, Atomic Structure, Atomic Symbol and Trends in the Periodic Table.

From the conclusions drawn, the following were recommended:

1. The game-based lesson developed for chemistry may be further enhanced by incorporating various game elements and integrating localized and contextualized game materials. This can help to engage and motivate students to learn, and ultimately improve their performance.
2. The games used in every classroom setting may be modified constantly to meet the needs of different learners and develop the desired competencies.
3. Science educators may utilize to further validate Game-Based Learning (GBL) as a means to enhance their students' academic performance and attain higher levels of achievement.
4. Future research on the development of game-based lessons is encouraged to reinforce in teaching various fields of science and across different disciplines at grade levels.

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