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Enhancing Performance in Chemistry Through Game-Based Strategies: An Experimental Study

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INTRODUCTION

The Problem and its Background

Integrating game-based strategies into chemistry curriculum is a superior educational intervention that greatly improves student performance and recall of abstract chemical principles. A study conducted by Liu et al. (2014), when game-based learning (GBL) is created with a strong pedagogical foundation, it can greatly increase student engagement and scientific comprehension by putting students in the position of active "problem-solvers."

Enhancing performance in chemistry fosters the development of critical thinking, problem-solving skills, and a comprehensive understanding of natural phenomena, which are essential for both academic and professional advancement according to Varenina, et al., (2021). One significant issue is the use of memorization rather than conceptual comprehension, which limits meaningful learning, particularly when it comes to chemistry systems and rearrangement reactions as emphasized by Grove et al., (2012). Confusion and frustration result from the inability to grasp molecular structures, comprehend chemical formulas as images of the physical world, and understand complicated concepts like interaction, polarity, and reactions involving acids and bases (Anim-Eduful et al, 2022).

A study of Kalir et al. (2017), "playful partnerships" are more important for the success of game-based learning (GBL) than the technology itself in areas with little resources, particularly in the Belizean primary education system. The authors argue against a "one-size-fits-all" approach by describing a cooperative effort between the University of Michigan and local stakeholders in Belize. Instead, they support the co-design of courses that are pedagogically and culturally relevant. The study emphasizes the value of capacity building, which enables local educators to overcome technical obstacles like inadequate hardware, and social scaffolding, where learning is motivated by human connections. In the end, the research indicates that Game-Based Learning must emphasize place-based learning that honors each student's distinct geographic and cultural identity if it is to be successful in a global setting.

Several studies from different nations have examined the issue of chemistry students' performance, pointing out a variety of aspects that influence success. In fact, a study conducted by Audu, et al., (2025) in Nigeria examined how students viewed their poor performance on chemistry exams and realized that low performance is largely caused by instructional problems, including inadequate training, insufficient teaching strategies, a lack of teaching resources, and a lack of experience. Another recent study of Kekeba, et al, (2025) discovered an excellent relationship between undergraduate students' performance in chemistry and their attitudes about the subject, their usage of science labs, and their teaching strategies.

Moreover, at Ilocos Sur National High School in Ilocos Sur, Philippines, a study was conducted by Sagcal, (2025). Its main goal was to help grade 11 students become more proficient in general chemistry by creating hands-on laboratory exercises. The study tackled problems including scarce lab supplies and students' challenges putting theoretical ideas into practice, suggesting creative, locally relevant hands-on activities to improve learning results.

Locally, engaging Grade 11 STEM students in chemistry exercises is an ongoing challenge for teachers in the Monkayo East District, especially at Union National High School. Chemistry is often considered by students to be confusing and challenging, which lowers exam scores and reduces student participation. Although traditional methods of instruction have been the standard, educators are interested in trying out game-based teaching strategies to improve student engagement and problem-solving abilities. Therefore, the purpose of this study is to investigate how well gamification might improve performance in Chemistry of Grade 11 students in this local setting, providing to the body of knowledge in education and useful classroom innovations.

Understanding specific learning gaps in basic chemistry concepts among students, especially with regard to keeping capabilities after finishing previous grade levels, is an important academic issue. Few studies have carried out thorough diagnostic tests to determine which chemistry topics students struggle with the most and how much these problems persist over time, despite the fact that prior research has identified factors like teaching strategies, resource availability, and student attitudes as key factors. To generate targeted approaches that can enhance mastery of important concepts and promote deeper, long-term comprehension, this gap must be filled. Closing this gap will benefit society by improving the standard of scientific education generally and giving students the tools they need to succeed in STEM fields. By helping underprepared students, lowering achievement gaps, and eventually developing a scientifically literate society that can innovate and make well-informed decisions in the fields of technology and health, improving chemistry learning outcomes advances equity in education.

Review of Related Literature

Using published journals, internet news, web reports, books, and other relevant sources, the researcher thoroughly reviewed the body of literature to support and reinforce the study on improving chemistry performance using game-based strategy.

Game-based Strategies. A process of incorporating game design elements like scores, levels, challenges, and rewards into educational settings to improve student motivation, involvement, and active engagement. As stated by Terrell (2016), who conducted a study on gamification for teaching APA style, students were more motivated to participate when learning activities were presented as game-like challenges because rewards served as a form of accomplishment that motivated hard work and collaboration. This approach helped students view learning as a more enjoyable and interactive process.

A narrative review of gamification and game-based approaches in clinical education was conducted by Szeto et al. (2021), with a focus on their potential applications in patient outreach, dermatological student education, and general medical training. The review found that gamification frequently enhances learning reinforcement while increasing student motivation, engagement, and enjoyment when compared to traditional teaching methods.

In addition, Wang et al., (2010) examined the effects of preference-matching and game strategy on novice learners' programming performance and flow experience in game-based learning. They applied two game strategies: a challenging method that consistently delivers a high level of difficulty regardless of desire, and a matching-challenging technique that adapts the game challenge to individual preferences. In contrast to the matching-challenging group, the study discovered that learners who used the challenging technique experienced higher flow, which translates to greater immersion and engagement.

The use of game-based components generally increases learner motivation and engagement, according to a scoping review of gamification research; however, the actual improvement of learning outcomes heavily depends on strategic planning that takes into account the unique demands and contexts of the students. Additional empirical research on these game aspects reveals a certain hierarchy of usage, with points, badges, and leaderboards being used most frequently, followed in descending order by levels, awards, progress bars, challenges, feedback, and avatars. According to Tunç et al. (2023) and Alomari et al. (2019), these observations highlight that although gamification is a potent tool, its efficacy depends on the thoughtful selection of mechanics and proper alignment with the learning environment.

Moreover, interactive games helped Thai English learners learn phrasal verbs, according to a study by Kijpoonpol et al., (2018) on the use of gamified teaching methods to teach phrasal verbs. According to the authors, students' understanding of phrasal verbs improved noticeably, and they were able to comprehend and retain more phrasal verbs following the teachings.

Students' progress reveals how gamification and Ryan and Deci's notion of self-development relate to students' learning style. As previously said, gamified learning encourages students to actively participate in group discussions and independent and autonomous learning (Ding et al., 2020; Pham et al, 2021). Similarly, Tan (2018) asserts that meaningful gamification serves as a motivator for pupils to understand important language instruction themes.

Additionally, a study that investigated instructional computer games that were based on aspects of control, challenge, curiosity, and fantasy. Through the provision of immersive settings and interactive challenges, they discovered that game-based learning improves motivation and engagement, resulting in improved learning efficiency and collaborative learning opportunities. Adipat et al. (2021)

In a study conducted that used a theory-and data-driven strategy to investigate the nature and evolution of game-based learning engagement by Ke, et al., (2016). Affective engagement, which is driven by an ideal degree of challenge that piques interest and motivation, cognitive engagement, which entails playful interaction and involvement in the learning tasks, and content engagement, where students actively interact with and apply game-related content, are the three stages of engagement, according to their study.

According to the research that game-based learning fosters an engaging and dynamic learning environment, which is particularly advantageous in higher education. Through encouraging engagement and collaboration, gamification is in line with educational objectives, as seen by the positive effects they reported on students' views of learning and teamwork by Mostafapour,et al.(2020)

In a similar thought, a study investigated how well hydrocarbon-related chemistry content can be learned using gamification. Test scores, retention, and learner motivation were significantly improved when compared to traditional education, according to their experimental research (Lutfi, et al, 2023).

Furthermore, through meta-analysis, a study by Hu et al. (2022) showed that game-based learning in chemistry enhances cognitive outcomes like conceptual understanding and long-term retention, indicating that gamified instructional designs are in line with the objectives of chemistry education. More so, simulations and games are especially good at promoting student motivation and improving engagement in all kinds of learning contexts, according to this systematic review, which evaluates a number of studies on game-based learning (Sitzmann (2011).

A comprehensive literature assessment, games and simulations have a typically beneficial impact on learning objectives in higher education. Three main learning outcomes were identified by the study: affective, which includes self-evaluation and student motivation; behavioral, which involves the development of social, emotional, and collaborative skills; and cognitive, which includes comprehension of theoretical concepts and critical thinking according to Vlachopoulos et al., (2017).

In addition, Kuo et al., (2016) discovered that gamification has the ability to draw in, motivate, engage, and keep individuals in a distance learning setting. The behavior of users was greatly affected by important game design elements such discussion boards, web games, theme activities, and visual real feedback, indicating a connection between the theory and practice of online gamification in education.

The effectiveness of game-based learning (GBL) in improving junior high school students' mathematical problem-solving abilities was thoroughly investigated in the study by Pratama et al. (2018). The researchers saw significant increases in both cognitive and emotional outcomes by incorporating geometry principles into the interactive environment of GeoGame Adventure, particularly with relation to concept recognition and problem-solving skill. Through engaging, play-based challenges, this method successfully cultivates motivation and excitement within the mathematics curriculum.

Also, gamification is a very successful tactic for raising student achievement in a variety of areas. This method greatly increases motivation, engagement, and active participation by incorporating game components like challenges, badges, and points. According to the study of Kellman, et al., (2022), gamification improves cognitive outcomes like long-term retention, problem-solving abilities, and conceptual understanding in addition to making learning more pleasurable. Gamified learning environments are a useful substitute for conventional teaching techniques since they also promote positive affective and behavioral effects, such as enhanced self-confidence, teamwork, and excitement for the material.

In the same way game-based strategy relates an effective technique to promote peer teaching, cooperative problem-solving, and active communication is collaborative learning, which is strengthened by delegating clear group roles and tasks. You can guarantee accountability and concentrated engagement by assigning each student a specific position, such as presenter, researcher, leader, or recorder. These positions empower students to use and develop a variety of abilities within the group, as well as to participate in a variety of ways. As highlighted by Loes (2022), collaborative learning positively influences academic motivation and critical thinking by fostering peer interaction where students explain concepts to each other, reinforcing their own understanding.

Moreover, students have the chance to help one another get past academic challenges, especially in mathematics, through peer tutoring. assisting them in overcoming the obstacle they perceive to be challenging by offering a companion and establishing a connection with them that will boost their self-confidence and enhance their academic achievement (Candelaria, 2022). In the study conducted by Boonstra et al. (2017), students' positive dependency, accountability, and shared ownership are stimulated by structured collaborative assignments with clearly defined roles, which improves group effectiveness and communication.

A results of a certain study that learning is positively impacted by a game's difficulty both directly and through increased engagement. Hamari et al. (2016) argue that students are more likely to learn when they are actively involved.

Game-based learning merges the engagement of gameplay with specific learning objectives, assisting in the direct integration of instructional content into the gameplay and storyline of the game according to Plass, et al, (2015). In a game-based context, Eseryel et al. (2014) examined the connection between engagement, motivation, and complicated problem-solving. According to their findings, well-made games can help kids develop critical thinking and problem-solving abilities as well as self-regulation in task performance.

Furthermore, Chiotaki et al (2023) carried out a comprehensive analysis of adaptive game-based learning, which adapts to the unique requirements of each student. According to their findings, these adaptive systems can boost student motivation, perceived usability, and learning effectiveness.

A collaborative learning fosters active communication, accountability, and cooperation skills by having students work in small groups with designated tasks to accomplish common objectives as stated by Faculty Focus (2024), In addition, using collaboration scripts and group awareness tools improved domain-specific knowledge, higher-order thinking abilities, satisfaction, group task performance, and social interaction, according to Chen et al.'s (2018) meta-analysis of computer-supported collaborative learning (CSCL).

Additionally, a study conducted at Francisco P. Felix Memorial National High School in the Philippines, game-based activities are a good way to teach complicated chemical concepts. It was suggested that these activities be used in the classroom to help students perform better and acquire more skills (Cabrera, 2024).

It is commonly known that game-based techniques improve students' academic performance in a variety of subject areas. For example, a meta-analysis of the effects of online teaching strategies and learning cycle models on chemistry students' academic achievement revealed that these methods, which frequently include interactive or game-like online components, had a comparatively significant and positive impact on students' academic development (Vallespin & Prudente, 2024). Furthermore, research on digital game-based learning has shown that it improves students' learning outcomes in STEM courses, especially in terms of information acquisition and retention (Huang, Liang, & Chou, 2017).

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Other studies have shown that by increasing student motivation, engagement, and positive attitudes, game-based interventions can dramatically increase academic performance in particular abilities, such vocabulary and grammar (Haleem, 2022). These results highlight how adding games can change the learning process from a passive assignment to an engaging and dynamic challenge, which will improve academic outcomes.

Balancing Chemical Equation Game: An investigation created by Atanan et al., (2020) a computer game was developed and assessed to improve high school students' ability to balance chemical equations. The results showed that the mean learning achievement was considerably higher after playing the game than it was before. Also, the students conveyed remarkable contentment with the game, indicating that it was not only efficient but also captivating and easy to use.

Likewise, a conducted study that taught younger students the fundamentals of balancing equations before they were formally taught chemistry using a "sandwich-making" computer game by Sorensen, et al., (2018) . Games can aid students in understanding the mathematical and combinatorial concepts of balancing, as evidenced by the results, which indicated that the skills they acquired from the game translated to their subsequent ability to balance basic chemical equations.

Additionally, Singh, et al., (2015) conducted a study in teaching balancing chemical equations using games greatly increased students' confidence and conceptual knowledge. Inquiry-based particle worksheets and a three-tiered concept test were used in this two-phase action study to collect both qualitative and quantitative data. Following the game-based intervention, the students' perceived confidence and conceptual knowledge were found to be moderately positively correlated. This shows that teaching this difficult chemical idea to Class VIII pupils through a game-based method was a successful educational tool for enhancing their cognitive and affective learning.

PhET interactive simulations were a more successful way to teach balancing chemical equations than PowerPoint presentations. The success of the simulation, according to the authors, may be ascribed to its capacity to offer an interactive, captivating, and visual learning experience that enables students to observe the process of balancing equations and get a deeper comprehension of the fundamental ideas, Bhatti, et al., (2021).

Chemistry instructors have positive perceptions about using simulation games to teach chemical equation balance. They noted certain difficulties even though they agreed that these resources make the course more interesting, interactive, and learner centered according to Assafuah-Drakow's (2018). The teachers thought simulation games were a useful teaching tool that could greatly enhance students' comprehension of the subject.

In the end, teaching students how to balance chemical equations through games and interactive simulations is a successful teaching method. Research continuously demonstrates that this method dramatically raises students' confidence, conceptual understanding, and learning outcomes. Despite certain practical difficulties, chemistry teachers also have a favorable opinion of these technologies and recognize their potential to enhance interactive and learner-centered instruction.

One of the core chemistry skills that students can practice with this game is balancing chemical equations. Students gain competence in recognizing reactants and products and using the Law of Conservation of Mass by participating in interactive missions or projects that resemble real-life situations (such as balancing chemical reactions connected to beaches). Research has indicated that computer-based balance games enhance learning outcomes and cultivate favorable attitudes toward the idea, making the process of learning fun and approachable. Chemical equations balancing understanding and retention are improved by the game's repeated practice, immediate evaluation, and self-paced learning.

Lewis Dot Structure Game: An instructional tool called a Lewis Dot Structure Game aids students in visualizing and practicing the drawing of Lewis dot structures, which stand in for atoms' valence electrons and the bonds they form with molecules. In order to assist students, comprehend how atoms share or transfer electrons to form covalent or ionic bonds, the game usually consists of placing dots around element symbols to depict electron pairs and bonding lines. Students' comprehension of chemical bonding principles such as the octet rule, lone pairs, and numerous bonds is improved by this participatory method, which gives abstract notions a more tangible and interesting form.

In the study of Nassiff and Czerwinski's (2015), teaching Lewis's dot structures in basic chemistry classes can be accomplished successfully with a streamlined, step-by-step approach. Students were able to grasp the idea of sketching basic Lewis structures fast and effectively because to this teaching method, which focuses on a clear process. The authors came to the conclusion that this method's planned and methodical approach helped pupils avoid typical mistakes like miscalculating bonds or running out of electrons.

The Lewis Structure Explorer, a computerized tool that provides students with real-time feedback on formal charges, bonds, and electron counts while they build Lewis structures as emphasized by Wegwerth (2024). Due to features like keyboard navigation and thorough alt text descriptions, it is particularly accessible to students who are blind or have impaired vision. According to usability studies, it facilitates precise and autonomous Lewis's structure learning, making it an effective tool for inclusive and significant chemistry instruction.

Additionally, the cognitive load chemistry students faced when building Lewis structures was examined in the Tiettmeyer et al. (2017) study. The findings showed that for inexperienced pupils, adding nearly any structural feature to the picture considerably raised cognitive load.

According to Paye et al. (2021), their "Lewis Structure Builder" software helped students study organic chemistry review and improve their skills. For 21% of participants, the app's user-friendly, game-like interface with real-time feedback resulted in better results, and most students thought it was a positive and helpful learning tool.

Similarly, an investigation discovered that Kahoot! as a gamification tool greatly enhanced pupils' comprehension of Lewis Dot structures and electron arrangement. Higher academic achievement and improved conceptual understanding were the results of the gamified tests' greater motivation and engagement according to Abao et al., (2025). Students that regularly played Kahoot! activities demonstrated significant improvements in learning outcomes as compared to those that did not, confirming Kahoot! as a useful instrument for improving chemistry instruction using engaging and entertaining techniques.

In order to enhance the instruction of ionic and covalent bonding, Debit, et al., (2024) created a board game called "GamesBond." Students' comprehension and academic achievement were greatly enhanced by the game in comparison to more conventional approaches. It adhered to social constructivist ideals by actively involving students, fostering peer connection, and fostering meaningful learning through teamwork.

Likewise,a study evaluated a formal charge method that was created to make creating Lewis's dot structures easier quantitatively. Two student groups were compared in the study: one was instructed in the formal charge way, while the other was instructed more conventionally, Curnow et al., (2023). The formal charge method helped students identify the right Lewis structures with fewer attempts and resulted in a 5% improvement in scores, according to the results. These gains were statistically significant, suggesting that the approach was successful in raising students' precision and productivity when building Lewis structures.

Further, McArdle (2019) presented a methodical two-step process for creating Lewis structures that explicitly includes donor bonds and gives priority to electron pairing. This technique differs from conventional methods in that iteratively forms bonds until octets are satisfied by concentrating on molecular connectivity and valence electron counts. Formal charges are calculated using formulae; instead, donor bonds are added between atoms with six to eight electrons, and charges are modified appropriately. To improve student comprehension and engagement, the study highlights the importance of following the octet rule for p-block members and provides software that enables interactive 3D visualization of Lewis structures.

Furthermore, a certain study looked at how first-year college students use problem-solving to learn how to draw Lewis structures, Kaufmann, et al., (2017). They discovered that although the formal drawing process is crucial, students use its steps in a flexible way based on the context of the problem and their understanding of chemistry. In order to foster a deeper understanding than merely applying principles like the octet or formal charges, they propose teaching Lewis structures as an iterative process of construction, checking, and modification. This approach encourages more thorough and adaptable molecular structure reasoning.

Lim (2018) argues that the octet rule's conventional application in Lewis's structure instruction frequently results in misunderstandings. The study points out that concentrating only on the octet can oversimplify ideas of chemical bonds and that many elements exhibit deviations to the octet rule, such as enlarged or incomplete octets. To enhance comprehension, the paper suggests teaching Lewis structures using real electron distribution and bonding properties that have been shown experimentally and through contemporary quantum chemistry, rather than the strict octet framework.

Moreover, a new Lewis structure model that aims to enhance comprehension of organic reaction mechanisms. By explicitly depicting valence electrons as dots and core electrons as lines. Zhou et al., (2023) discovered that this novel model makes it easier to see electron movement and bond formation/breaking. In addition to clearing up common misunderstandings about electron transportation and simplifying the study of intricate reaction mechanisms, this method has been demonstrated to be successful in giving students and teachers a more accurate and intuitive picture.

Furthermore, Peragovics et al., (2021) highlights how important structure drawing is to teaching chemistry. They talk about how crucial it is for students to understand a variety of structural representations, such as three-dimensional models, Lewis structures, and resonance forms. To improve student engagement and comprehension, the researchers introduce Zosimos, an online application that lets teachers generate assignments and quizzes with instant feedback. Their work with fifth graders demonstrates how incorporating these interactive resources into the classroom facilitates efficient chemical structure learning and visualization.

To elaborate, teaching Lewis's dot structures is significantly simplified by interactive material and educational games. Research continuously demonstrates that simpler approaches and game-like applications increase engagement, improve conceptual understanding, and lower common mistakes. All things considered, these techniques effectively help students understand the concepts of chemical bonding by making it more concrete and intuitive.

The goal of this game is to educate students how to visually represent molecules using Lewis's dot structures, which show valence electrons and molecular bonds. Students learn how to create bonds, arrange electrons appropriately, and comprehend molecular geometry through interactive challenges or puzzles. This improves conceptual understanding of chemical bonding, electrical configuration, and atomic and molecular structure. The use of games encourages critical and visual thinking in students, turning abstract ideas into concrete, intelligible representations. It also helps students develop their problem-solving abilities by making them forecast the stability and bonding patterns of molecules.

Atomic Structure Game: A game that teaches students about the internal structure of atoms including protons, neutrons, and electrons as well as ideas like ions and isotopes is called an "atomic structure game." These games encourage active and generative learning through the visualization and manipulation of subatomic particles. They frequently include tactile pieces, cards, or digital simulations to enable hands-on assembly of atomic models. Students' comprehension of atomic properties is enhanced and teamwork is encouraged as a result of the games' engagement with tasks like building atomic models and choosing and organizing data from the periodic table. Research indicates that these games enhance students' motivation and mental understanding, making complex atomic concepts more approachable and significant.

Similarly, in the study conducted by Girón et al (2023) discovered that the educational game "Atomizados" greatly enhanced the comprehension of atomic structure among Grade 9 students with learning disabilities. 63.63% of students achieved an educated comprehension, exceeding control groups, because to the game's use of tactile cards and chips, which encouraged active and collaborative learning. Additionally, students reported being highly engaged and participating positively in class.

More so, Nkadimeng (2020) investigated the use of Minecraft as a teaching tool for atomic structure to eighth-grade Natural Science students. The findings indicated that Minecraft improved students' critical thinking, motivation, and teamwork. Through investigation and practical application, the game improved comprehension by giving the abstract idea of atomic structure a more tangible and interesting form. As they collaborated, students were forced to exercise critical thinking, showcasing Minecraft's potential as a useful teaching tool for science classes.

Creating an atomic game-based learning tool proved to be a successful and interesting way to teach chemical fundamentals. Students that played the game reported having a good and enjoyable learning experience, and the results revealed that their cognitive knowledge had improved. By boosting student motivation and interest in chemistry, the study demonstrated that a well-made game can be a good substitute for conventional teaching techniques as stated by Rahman et al.'s (2020).

As emphasized in Miller's (2013) dissertation created a number of practical atomic structure exercises for high school science students, such as a model of Rutherford's gold foil experiment that clarified the atom's small, compact nucleus and largely empty space. They also played a game called Electron Battleship to practice electron configurations and used marbles to represent electron probability distributions as they explored the quantum model of the atom. Students demonstrated high levels of engagement and performance as a result of these interactive, inquiry-based assignments that sought to enhance their comprehension of atomic models, quantum theory, and electron configuration notation.

Similarly in the study concentrated on creating and evaluating a "Chemopoly" game for Android that teaches atomic structure. According to the findings, the game was judged to be "very feasible" as a teaching tool, Faoziah, et al., (2023). The researchers came to the conclusion that the game's design, which combines chemical ideas with the rules of the traditional board game, makes it a legitimate and useful instrument for involving students and assisting them in understanding atomic structure in an entertaining and interactive manner.

Furthermore, Kurushkin et al., (2016) study reinforced students' understanding of atomic structure by introducing "Orbital Battleship," a competitive, guess-based game based on the original Battleship game. Each player selects an element and uses orbital occupancy to represent its electron configuration. They then alternately guess the opponent's electron positions using quantum numbers. This game increases motivation and engagement in learning atomic structures, enhances comprehension of electron configurations, and promotes the application of Madelung's and Hund's laws. Unlike traditional approaches, the game is renowned for being participatory, encouraging greater involvement and critical thinking.

Additionally, the effects of the "Go-Chemist! mobile application that encourages children in Grade 10 to study atomic structure. With 71 students in a quasi-experimental design, the app-using experimental group had a markedly higher level of motivation than the control group, which was instructed using conventional textbooks, Lukman, et al., (2023). The software supported anytime, anywhere learning and increased student engagement and relevance to their everyday lives. According to the findings, Go-Chemist! successfully raises student motivation and is suggested for incorporation into chemistry instruction.

More so, Nuhari, et al., (2025) examined how Grade 10 students' learning results on atomic structure could be enhanced by using the Uno card game. To identify atomic particles, ions, and isotopes, students utilized the game as an interactive learning tool to gather random data. According to the results, students in the experimental group who played the Uno card game made more progress and had a better comprehension of atomic structure than students in the control groups who received instruction using conventional methods.

A study created interactive chemistry learning materials on atomic structure using Animaker, an AI-powered animation platform. The media's captivating animations, lively graphics, and sound effects made the information more approachable and easier to comprehend. The media greatly boosted student attention and comprehension, as confirmed by specialists and well accepted by educators and learners. It is regarded as a useful, adaptable, and efficient tool for both in-person and online instruction, improving student participation and atomic structure learning results, according to Ummahati et al., (2024)

As emphasized by Leaño (2023), Grade 8 students' academic performance in chemistry subjects like atomic structure, particle nature of matter, and characteristics of matter was much enhanced by game-based lessons.

Throughout the lessons, students remained engaged and motivated due to the interactive nature of the games. These results suggest that in improving chemistry education through interactive, entertaining, and learner-centered methods, game-based approaches can successfully support conventional teaching methods and raise student academic achievement.

Finally, educational games are a very useful instrument for teaching atomic structure and associated chemistry ideas, according to the texts that are provided. All of the games described improved student learning and engagement, according to the study. In particular, these activities enhance students' motivation, critical thinking, conceptual knowledge, and teamwork. Making abstract concepts more interactive, vivid, and tangible like atomic orbitals and electron configurations is how this is accomplished. The study demonstrates that these game-based approaches are a legitimate and frequently better substitute for conventional teaching techniques, producing notable gains in student performance and attitude.

This game promotes students in comprehending subatomic particles, electron configurations, isotopes, and periodic trends, all of which are intended to enhance comprehension of atomic theory and the nature of atoms. Students can visualize difficult ideas and carry out virtual experiments by simulating atomic models and related events. According to research, well-made educational games can boost engagement, encourage active learning, and enhance knowledge of atomic structure, particularly for students who struggle. By making unseen atomic processes clear and accessible, this interactive method promotes cognitive development and improves academic performance.

Student Performance in Chemistry: As a subject, chemistry is widely acknowledged as a subject that calls for creative teaching strategies to overcome students' difficulties grasping abstract and difficult ideas. More recent research, of Seery (2020), has demonstrated that using active learning strategies, like problem-based learning and converted classrooms, greatly improves student performance in chemistry.

As emphasized by Toma et al., (2018) the reciprocal relationship between learning results and motivation is highlighted in this article. It makes the case that activities that raise student motivation like making chemistry more applicable or practical, which can result in a positive feedback loop that increases effort and enhances comprehension.

Moreover, Chemistry Education contains teaching, lab experimentation, and evaluation to help students develop strong concept understanding as well as problem-solving abilities.

In addition, the use of strategies by students, such as appearance matching, to reduce their mental load can result in incorrect chemical reasoning, according to more recent cognitive research. Teaching that makes those methods visible and offers structured practice with representations can enhance analytical thinking (Talanquer, 2014).

Further, when compared to traditional methods of instruction, gamification significantly enhances students' learning outcomes, motivation, and engagement, according to experimental studies in chemistry education. For example, Manipon et al. (2023) employed "ChemiCooking," a gamified educational e-game involving chemistry symbols, in an experimental study with Grade 11 students. Learners introduced to the game’s intervention showed noticeably higher post-test scores than the control group in the study, which included control and treatment groups. This suggested that students' performance levels and information learning were improved by gamification. The study also found that the use of dynamics of the game and involvement in the instructional materials enhanced student motivation and engagement.

According to a related study, students in the experimental group outperformed the control group in terms of learning outcomes, motivation to keep learning, and knowledge retention when using the "Hydrocarbons Chem-Rush" game as a teaching tool. These results are consistent with earlier studies that show game-based learning encourages engagement and enhances chemistry students' academic performance (Lutfi et al., 2023; Funa et al., 2023).

Another study conducted with high school students in Indonesia showed that, in comparison to traditional instruction, gamification, the use of computer-assisted games, significantly improved learning completeness and post-test results in atomic and molecular chemistry (Lutfi et al, 2021).

Moreover, Hudsonet al., (2013) conducted a study of examination data from an Australian university chemistry course, emphasizing the cognitive levels evaluated and the conceptual application skills of the students. The findings demonstrated that both forms of assessments offered valuable data in complimentary ways. While multiple-choice questions provided information about students' basic conceptual understanding and recall, short-answer questions were better at evaluating higher-order cognitive abilities including application, analysis, and problem-solving.

All things considered, this experimental research offer strong evidence that using gamification strategies in chemistry instruction improves learner comprehension, motivation, and retention. By providing interactive and easily accessible educational content, digital learning technologies in Kenya improve student engagement. Students can advance at their own level thanks to these technologies, which facilitate personalized learning. Effectiveness, still, may be affected by issues like poor internet access and low levels of computer competence among educators. Despite these challenges, Kenyan students' performance has improved because of the use of digital technologies. (Mwangi, 2024)

Similar findings were made by Santhanalakshmi et al., (2021), who found that PALS effectively enhanced the science performance of secondary students by promoting collaborative learning, in which peer tutors and tutees gain from structured interaction, which improves concept understanding and retention. In addition, another study by Sáez-López et al. (2017) emphasized the advantages of collaborative group work and peer support on academic outcomes and social and emotional well-being, emphasizing how these methods promote engagement and reduce anxiety.

Moreover, these studies show how collaboration in learning and supportive peers enhance students' exam scores, understanding of concepts, and problem-solving abilities in chemistry classes. Educational research supports the idea that skills in mathematics greatly improves problem-solving abilities by promoting logical reasoning, critical thinking, and the ability to break down difficult situations. The findings showed that the instruction had a significant impact on students' performance in both basic and geometry problem-solving. On the chosen tests of mathematical problem-solving, students who scored higher on friendships and social acceptance on the pre-test also performed better (Klang et al, 2021).

Further, figuring out the problem, developing a suitable method (solution), effectively applying the strategy, and evaluating the solution are all critical components of a successful problem-solving process. It means the ability of the students to grasp and solve the problem determines how well they learn mathematics. Students learn mathematics more effectively when they have a solid foundation of the problem-solving process. Students' difficulties in solving problems, which influence their low results in mathematics learning, indicate that they do not understand the concepts and operations of mathematical calculations. (Senaga et al.,2023)

In a study of Bird (2010), discovered that the capacity to reason logically is a strong indicator of general chemistry performance among students. The study assessed students' proficiency in six logical reasoning modes: mass/volume conservation, proportional reasoning, control of experimental variables, probabilistic reasoning, correlation, and combinatorial reasoning. Students were categorized into cognitive levels (concrete, transitional, and formal operational) using the Group Assessment of Logical Thinking (GALT) test.

Furthermore,a study that investigated how students' success in organic chemistry at a large, urban public university was influenced by their help-seeking behaviors and past chemical ability. Horowitz,et al., (2013) research, students who actively and strategically sought academic assistance, by going to office hours and problem-solving sessions, for example, performed higher than those who did not. The study discovered that, even after adjusting for past general chemistry performance, there was a statistically significant positive correlation between asking for help and better exam results.

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In the Science, Technology, Engineering, and Mathematics (STEM) track of senior high school in the Philippines, chemistry is still a required course. But both classroom-based evaluations and national tests frequently indicate that students struggle with higher-order problem-solving tasks in subjects like chemical bonding, gas laws, and stoichiometry (Department of Education [DepEd], 2019).

Filipino students' performance in science is below the OECD average, according to the 2018 Program for International Student Assessment (PISA), with problem-solving being listed as a critical area for development (OECD, 2019). To close these learning gaps, active learning techniques such as gamification have gained popularity in recent years.

THEORETICAL FRAMEWORK

This study was anchored in Vygotsky's Zone of Proximal Development (ZPD) theory, which highlights the value of guided learning and social interaction in cognitive development. Vygotsky defined the ZPD as the set of tasks that a student has trouble doing on their own but can complete with help from a more experienced person, like a teacher or a peer. According to this theory, learning is most successful when faced with new problems that are within this range beyond one's current skills yet attainable with assistance.

Vygotsky's (ZPD) theory, which highlights the need for social contact and directed help in learning, can serve as the foundation for both game-based learning and traditional methods of instruction. The ZPD, in Vygotsky's view, is the range between what a student can do on their own and what they can do with assistance from a more experienced person.

When used as part of a game-based strategy, educational games act as interactive scaffolds that keep students in their zone of competence (ZPD) by offering opportunities for group problem solving, challenges that are appropriate for their current skill level, and instant feedback. This increases motivation and promotes deeper conceptual understanding.

On the other hand, scaffolding is also used by conventional teaching techniques like direct instruction and teacher-led demonstrations, which provide supervised assistance and progressively transfer ownership to the learner as competency grows. By supporting learning that pushes students' abilities slightly past their independent level and encouraging their intellectual growth through organized support and active participation, both strategies are in line with the ZPD framework.

These methods establish a structured link between a student's prior knowledge and the intricate demands of advanced scientific expertise by basing game-based chemistry instruction in the Zone of Proximal Development (ZPD).

According to this theory, the game serves as a "more knowledgeable other," using customized "quests" and real-time feedback loops to keep students inside their ideal cognitive threshold—a state of flow where the content is neither too easy to be boring nor too hard to be annoying. Students may view and work with abstract variables, including molecular interactions and periodic trends, which are frequently invisible in traditional lectures, thanks to this interactive environment's crucial scaffolding.

Hence, this method successfully lowers cognitive load and resolves comprehension gaps through repeated trial and error by changing the learner's position from a passive recipient of formulas to an active investigator. In the end, the collaborative and guided nature of the gaming environment guarantees that deep knowledge and long-term retention are attained through meaningful, joyful involvement when chemistry is "played" rather than just studied.

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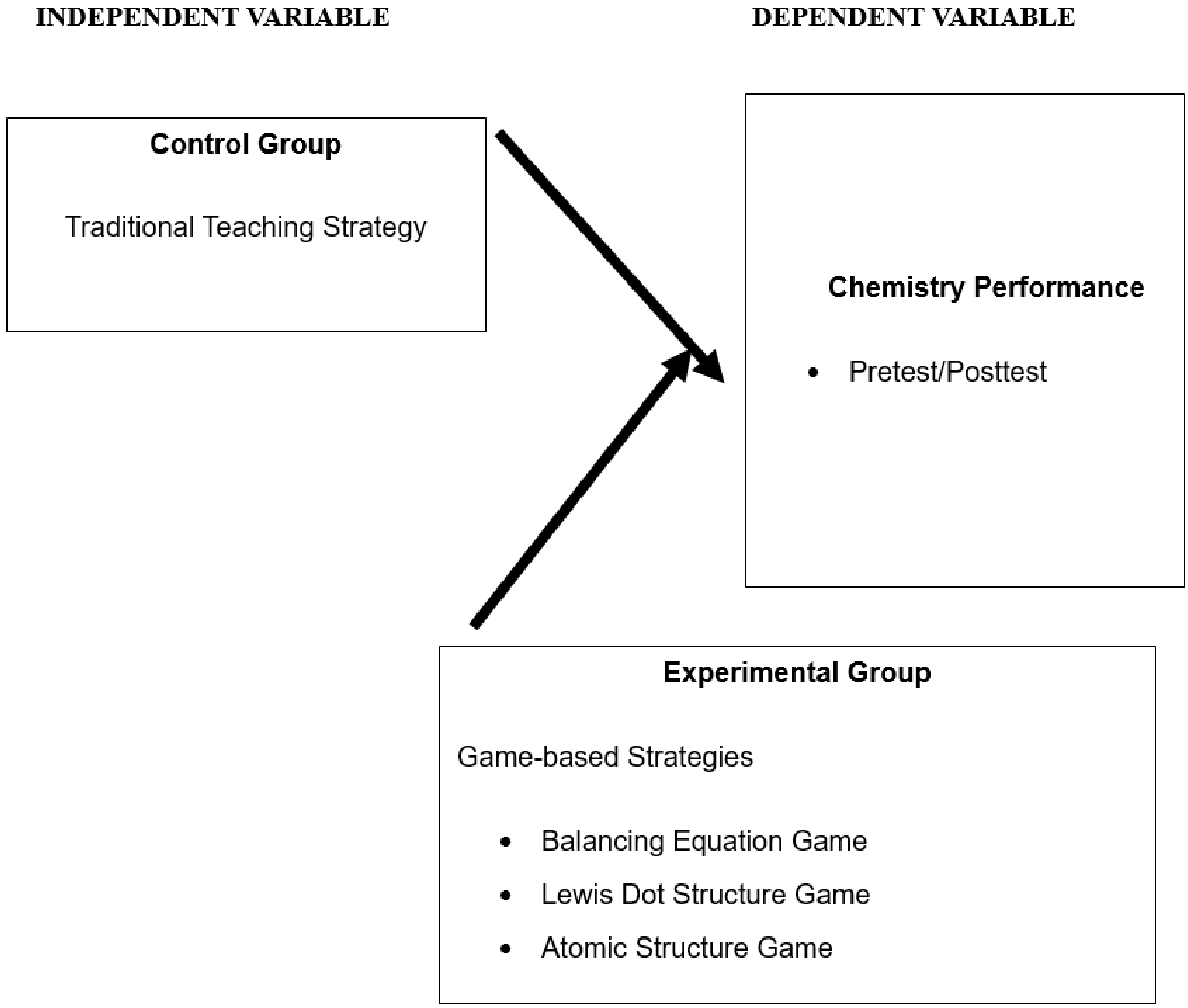

Figure 1. Conceptual Framework

Statement of the Problem

The study aimed to determine the effectiveness of game-based strategies to enhance performance in Chemistry. It sought to answer the following questions.

1. What is the competency level of the students in chemistry as reflected on their pretest results in terms of;

1.1 Control group; and

1.2 Experimental group?

2. What is the competency level of the students in chemistry as reflected on their post-test results in terms of;

2.1 Control group; and

2.2 Experimental group?

3. Is there a significant difference in the pretest scores of the students in chemistry between the control and experimental group?

4. Is there a significant difference between the pretest and post-test of the students in chemistry in terms of the control group?
5. Is there a significant difference between the pretest and post-test scores of the in chemistry in terms of the experimental group?
6. Is there a significant difference in the post-test scores of the students in chemistry between the control and experimental group?

Null Hypotheses

The study was treated extensively and accurately at a 0.05 level of significance.

Ho$_1$: There is no significant difference between the pretest scores of the students

in chemistry in terms of the control and experimental group.

Ho$_2$: There is no significant difference between the pretest and post-test of the students in chemistry in terms of the control group.

Ho$_3$: There is no significant difference between the pretest and post-test of the students in chemistry in terms of the experimental group.

Ho$_4$: There is no significant difference between the post-test scores of the students in chemistry in terms of the control and experimental group.

Scope and Delimitation

The study aimed to determine the effectiveness of game-based strategies to improve the academic performance of the students in chemistry. This was conducted at Union National High School Monkayo East District for the school year 2025-2026. The focus was on the classroom application of traditional teaching strategy and game-based strategy to 40 Grade 11 students.

During the duration of the study, two assessments were conducted in chemistry: pre-test and post-test. This was conducted before and after the intervention to measure the effectiveness of the strategies being implemented. During the conduct of the study, the two Grade 11 sections were divided into two groups as the control and experimental using the simple random sampling specifically draw lots method.

Significance of Study

This section outlines the several areas that stand to gain from the research's findings and the results.

Learners: The results of the study would make chemistry easier and enjoyable for them by providing an interactive and interesting learning environment that can enhance motivation, engagement, and memory of challenging chemistry ideas.

Teachers: The results of the study would encourage them to innovative instructional materials to accommodate a variety of learning styles and encourage student-centered learning.

School Administrators: The results of the study would help them gain from using research-proven techniques to raise student achievement and general school performance, which can aid in curriculum creation and resource distribution.

Deped Officials: The results of the study would help them acquire important knowledge on sustainable and successful methods for changing science teaching, especially in terms of increasing interest in chemistry and lowering rates of failing.

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Future Researchers: The results of the study would serve as a guide on researching the impact of game-based learning on various subjects, learner demographics, and educational situations. This would also encourage them to further explore other game-based strategies to help improve student performance in chemistry and other subject areas.

Definition of Terms

The following important terms are defined operationally that helped readers better comprehend the study.

Academic performance in chemistry: This term refers to the student's measured achievements or academic success in the subject. It includes the comprehension, application, and demonstration of chemical concepts, abilities, and problem-solving skills by students through tests, assignments, hands-on experiences, and academic work.

Atomic Structure Game: An educational game that uses atomic models to teach ideas like subatomic particles, electron configurations, isotopes, and periodic trends. In order to enhance understanding, the game encourages interactive investigation of atomic components and makes it easier to visualize the concepts of atomic theory.

Balancing Equation Gam: An interactive learning exercise aims to teach students how to balance chemical equations by modifying reactant and product coefficients in order to adhere to the Law of Conservation of Mass. With interesting, contextualized tasks, this game improves students' ability to recognize an equivalent amount of atoms on both sides of a chemical reaction.

Game-Based Strategy: This term refers to a teaching methodology that incorporates games or elements of games into the teaching and learning process to encourage active participation, motivation, and student engagement. To improve students' problem-solving abilities and general academic performance, this study focuses on the use of structured games that teach specific chemistry topics, like stoichiometry, chemical bonding, and chemical processes.

Lewis Dot Structure Game: A game that enables students to visually represent molecules by placing valence electrons around element symbols to show bonding and lone pairs, students can graphically represent molecules in this game.

Traditional Teaching Strategy: This term refers to the traditional, teacher-centered teaching methods in which students are passive recipients of knowledge and the teacher teaches through lectures, discussions, and demonstrations.

METHODS

The procedures and methods used in the study are covered in this chapter. It covers research procedures, statistical data management, research instruments, research instruments validation, research subjects, research location, and study design**.**

Research Design

Quantitative quasi-experimental research, particularly the two-group pretest-posttest design, was used in this study. Quantitative research is the collecting and analysis of numerical data. It could be used to predict results, evaluate causality, identify trends and patterns, and generalize findings to broader groups (Bhandari, 2023)

A popular experimental research technique that uses two groups, a treatment group and a control group, is the two-group pretest-posttest design. The two-group pretest-posttest design is a classic experimental structure used to determine if a specific treatment or intervention causes a change in a participant group (Dimitrov & Rumrill, 2003) Random assignments are used to assign participants to these groups in order to avoid bias and guarantee comparability.

Before doing any intervention, both groups go through a pretest, or preliminary evaluation, that gauges the dependent variable. After that, the control group is not exposed to the intervention or experimental condition, but the treatment group is. The same measuring tools were used for a post test that is given to both groups following the intervention period. To assess the efficacy of the treatment, the design enables comparison of the two groups' performance changes from the pretest to the post test.

Research Locale

The study was conducted at Union National High School around Monkayo, Davao de Oro. This location was chosen because of its diverse student body, current chemistry performance issues, and willingness to use innovative teaching methods like game-based learning. The environment offers a representative framework for investigating how, in actual classroom settings, game-based activities can improve motivation and academic performance in chemistry.

The Municipality of Monkayo is situated in the Davao Region of the Philippines' Davao de Oro province on the island of Mindanao. With a population of roughly 93,937. Monkayo is the most populated town in the province, according to the 2020 census.

The municipality is referred to as the "Gold Ore Hub of Davao de Oro" because of its gold-rich terrain, especially in the barangay of Mount Diwata, also known as "Diwalwal," a hilly location famed for its gold ore resources. Approximately 7 kilometers from Población, Monkayo, Davao de Oro, where Union National High School, the mother school, is located in the center of the barangay.

Barangay Union as one of the barangays of the municipality of Monkayo, which is part of the Davao Region (Region XI). With 8,316 residents as of the 2020 census, it makes up roughly 8.85% of Monkayo's total population. With an estimated elevation of 90.9 meters (298.2 feet) above sea level, the barangay is located at roughly 7.8084° N latitude and 126.0944° E longitude.

One of the 21 barangays that comprise Monkayo, Union contributes to the socioeconomic and cultural fabric of the area. Its residents are members of the Mandaya Tribe, an indigenous group whose primary source of income is farming, with main crops including vegetables, rice, bananas, coconuts, rubber plants, and fruit trees.

Union National High School is known as "The Cradle of Human Virtues." Its mission is to uphold timeless Filipino values that represent traditional Filipino cultures, which are unwittingly vanishing in the present day due to Western influence through social media and technology.

Since the school provides equal access opportunities that complement DepEd's mission, vision, and goals for junior and senior high school, all students can benefit from this. Currently, about 468 students and 30 staff members, including teaching, non-teaching, and contract staff, attend Union National High School. The school has experienced rapid growth while maintaining its commitment to volunteerism and fostering strong stakeholder relationships.

The honor of being the first secondary high school in the Monkayo municipality belongs to Union Barangay High School, now as Union National High School. It was founded in 1988 on 2.2 hectares of property that a prominent Union family kindly donated, demonstrating the community's dedication to educational advancement. Beginning with just two teachers, the school embarked on a small but important journey to give local children access to secondary education.

From these modest beginnings, it has developed over time into a significant local institution that has shaped the academic future of many students in Monkayo. This founding history demonstrates the community's spirit of cooperation as well as the importance placed on providing local youngsters with educational opportunities.

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Figure 2. Map of Barangay Union Showing the location of the study.

Research Subjects

The study focused on 40 Grade 11 students from Union National High School. Because respondents were usually selected based on preexisting qualities or conditions, the researcher used universal sampling in the selection process which means that every member of the selected population is included as a research respondents. This method removes sampling bias by adding all individuals who fit the inclusion requirements, giving a comprehensive picture of the population being studied.

The inclusion criteria were the following: a. the students are enrolled in Grade 11 at Union National High School: (2) have a physical science subject connected to the study of chemistry; (3) are available during the study time, and (4) and demonstrate willingness and consent to take part in the research. These standards were intended to guarantee that the sample accurately and impartially represents the full population of interest, enhancing the validity and generalizability of the study's findings.

Students who did not meet the set requirements for participation, such as being absent from data collection or not giving their informed consent were excluded from the study. Subjects were informed of their right to withdraw from the study at any time without prejudice and penalty.

Data Gathering Procedure

The following steps were taken to ensure that the data extracted as a result of the conduct of the study was valid and reliable.

The researcher sought a certificate from the Ethics Review Committee and an endorsement letter from the dean of the graduate school at Assumption College of Nabunturan. Following the receipt of these documents, the researcher sent a letter to the Division Superintendent's Office requesting permission to perform the study.

After approval, the researcher submitted the authorized and permission letters to the principal of the school where the study was implemented. The research populations selected for the experimental study were also informed by the investigator.

In addition, the researcher performed the study in line with the finest ethical standards. No one's identity was revealed, and any important information were handled with greatest caution and anonymity.

The researcher used semi-detailed lesson plans and game-based learning methodologies to teach the concepts of chemistry. The framework for delivering structured lessons in each session was provided by the teacher's lesson plans, which were essential to this approach. Using the researcher's selected approaches, the pre-test and post-test instruments were constructed and modified to assess students' understanding and application of fundamental chemistry concepts.

Balancing Equation Game, which uses the SciChamp.com platform, was answered cooperatively by three groups of students. Ten chemical equations had to be balanced by each group in a certain period of time. An incentive was awarded to the team that completes balancing every equation in the shortest amount of time. By making sure equations are balanced, this exercise sought to improve students' proficiency with the Law of Conservation of Mass while also fostering their analytical and problem-solving abilities in a group setting. As students collaborate under time pressure to attain accuracy and speed, it also develops cooperation and time management skills.The competencies of learning chemical equation balance, comprehending atom conservation in chemical reactions, and using mathematical skills in chemistry problem-solving are all covered in this game within the curriculum framework.

Similar to the Balancing Equation Game, the Lewis Dot Structure Game on the ChemQuiz.net site used timed and collaborative elements. After being divided into three groups, the students had to complete quizzes that ask them to recognize and illustrate the proper Lewis dot structures for different atoms and molecules. Every group had a specific amount of time to perform the test, and the team that completes it the most accurately in the least amount of time received a prize. In order to promote both conceptual comprehension and critical thinking abilities in chemistry, this game attempts to improve students' proficiency in representing valence electrons, forecasting bonding patterns, and comprehending molecular structure.

Similar to the earlier games, the Atomic Structure Game on the SciChamp.com website has timed and competitive gameplay. The quiz covered atomic structure themes such as subatomic particles, electron orbits, atomic and mass numbers, valency, isotopes, cations, anions, and the first 20 elements of the periodic table. Students were divided into three groups and competed to answer the questions. The quiz had a time limit for each group, and the team that correctly answers every question in the least amount of time wins. By improving students' grasp of atomic components, elemental arrangement, and qualities in accordance with the periodic table, this game fosters teamwork, critical thinking, and time management abilities while also developing the competency to comprehend and apply atomic theory principles.

To measure the changes caused by an intervention, pre-tests and post-tests was administered. To determine respondents' baseline knowledge and to identify any initial differences between the evaluations applied, a pre-test was administered before to the intervention. The post-test was given to gauge any changes or advancements following the implementation of the lessons utilizing the traditional and game-based learning methodologies as approaches. The researcher was able to evaluate the effectiveness of the intervention while considering possible causes of confusion in mind by comparing results of the pre-test and post-test.

Research Instrument

For the pretest and post-test in this study, the researcher created a 30-item chemical questionnaire. With an emphasis on the traditional and game-based learning approaches, the questions were designed to gauge students' comprehension of chemistry concepts and problems. A Table of Specifications (TOS) was created to make sure alignment with Grade 11 competencies. The test was composed of 30 multiple-choice questions with four options each, divided into three categories: 60% simple, 30% average, and 10% tough. This tool served as the study's pretest and post-test.

The parameters that followed were used in relation to the analysis of the data: competency levels such as Beginning (0–25%), Developing (26–50%), Approaching Proficiency (51–75%), and Proficient (76–100%) were utilized to interpret the mean scores. Furthermore, a 0.05 level of significance ($p < 0.05$) was used to determine statistical significance; a p-value less than 0.05 indicates a significant difference, while a p-value greater than 0.05 signifies no significant difference. The analysis of student performance and the effectiveness of the implemented instructional strategies was driven by these factors.

Validation of Instrument

Expert evaluators validated the pretest and post-test instruments. The instructional approach used both traditional and game-based learning strategies to engage students in meaningful learning experiences that enhanced their comprehension, analysis, and application of numerical concepts, as well as their ability to accurately answer comprehension questions. The questionnaire was improved and pilot tested on fifteen students who were not study participants based on the validators' comments and recommendations. To evaluate the instrument's validity and reliability, the pilot test data were examined. Cronbach's alpha was used to determine reliability, and the results showed a value of 1.0, indicating that the test instrument has excellent internal consistency and is reliable for use in the study.

Statistical Treatment

The data acquired from the study was collected and organized to produce understandable conclusions. The SPSS application was used to analyze the data using the following statistical tests to carefully assess and interpret the various data acquired for this study.

Mean. This was used to determine the average scores of the subjects.

Paired t-test. This was also used in comparing the means of the pretest and post-test in each group, control and experimental.

Independent t-test. This was used in comparing the means of the pretest and post-test of the control and experimental groups.

Ethical Considerations

The study focused on grade 11 students, and it was necessary to treat them ethically. Therefore, the researcher strictly followed ethical guidelines during the research project to ensure the respondents' safety, well-being, and trust. In addition, the moral standards outlined in the Belmont Report (1979), which include beneficence, fairness, and respect for humankind, will be strictly upheld.

Social Value: Traditional and game-based learning was used in this study to thoroughly examine students' chemistry proficiency. Assuring ongoing motivation and performance in the face of various obstacles, the findings helped the Department of Education officials create policies, programs, and interventions that enhance instructors' understanding of the learning material and various techniques. By enhancing teacher teaching methods through the application of game-based learning methodologies, this project advances Sustainable Development Goal 4 (Quality Education).

Informed Consent: The informed consent approach guaranteed that respondents are completely aware of the goals, limitations and expectations of their participation. Since participation is completely optional, potential volunteers was aware of the Informed Consent Form (ICF) and their ability to discontinue at any moment if they feel uncomfortable. To encourage more considered responses, they were given the choice to take the questionnaire with them and was informed about how long the data gathering procedure will take. If study respondents are having trouble answering the questions, they were encouraged to ask questions or seek clarification. To formally express their willingness to take part in the study, individuals must sign the consent form.

Vulnerability of the Research Participants: The researcher provided a thorough explanation of the study survey, including the pre-test and post-test analyses, covering its purpose, time frame, and methods.

Respect for persons: This includes respecting the individuality of each person as well as protecting those whom freedom is impaired. The researcher promoted confidence, trust, and friendship while avoiding taking advantage of respondents' weaknesses, paying special attention to encouraging participants. The researcher demonstrated genuine concern for the respondents by keeping fully to the prescribed ethical guidelines. The researcher emphasized to the respondents' voluntary participation throughout the course of the study. Th study shall use informed consent and informed authorization, particularly for those who are minors. The researcher made sure that all willing participants have filled out and turned in their Informed Consent and Assent Forms before distributing the tests that were created for the study.

Privacy and Confidentiality of Information: To ensure adherence to the Data Privacy Act of 2012, all collected data was kept safe and secured. Throughout the study, the researcher guaranteed participants' privacy and data confidentiality. To further preserve privacy, all electronic files, including participants' data, were erased at the end of the study.

Justice: Pertains to treating participants fairly in order to divide the challenges and rewards of the study in an equitable manner, which will always be a primary ethical concern. The prevention of exploitation, especially among vulnerable communities, and the objective selection of participants remained crucial ethical considerations for researchers. In order to prevent any possible abuse of power or discrimination, researchers chose respondents who are not directly supervised by them in order to assure equal selection. Participation were carefully examined and kept private, the researcher assurances. The researcher made every effort to ensure that the facilities and equipment needed to carry out the study are available. With the assistance of knowledgeable statisticians, data was processed in a facility built for the extraction of exact information. All of the study's questions were relevant to the communities that are taking part, and the survey's administration was carefully planned to avoid any conflicts with the participants. From start to finish, strict adherence to the schedule was maintained.

After spending a significant amount of time on extensive research, seminars, workshops, and training, the researcher and the research advisor are both qualified to carry out the study. Both are licensed teachers currently working for the Department of Education, and the research advisor holds a master's or doctoral degree. They also received support from other sources, such as other educators, school officials, and a reputable panel of experts.

The researcher ensured that all personal information, study methods, results, and findings are kept completely secret. Information provided by respondents was kept private and anonymous to prevent unauthorized access. Respondents did not suffer any harm from the study, and compliance with the Data Privacy Act of 2012 (RA 10173) was given top priority, particularly with regard to safeguarding sensitive personal data. In handling the data collected, the researcher followed ethical guidelines and the Data Privacy Act, guaranteeing that respondent names were kept private and that data was safely preserved and only accessible by authorized individuals. Results were derived only from the data gathered and were not altered to suit outside objectives. The researcher sought outside assessment of the study's methods, data, analyses, and conclusions in order to maintain academic integrity. This preserved credibility and enhanced the larger body of knowledge regarding teacher resilience in flood-affected schools.

Transparency. By making sure that every process, methodology, and finding is painstakingly documented, the researcher demonstrated their commitment to complete transparency throughout the study. Although there was a clear disclosure of any potential conflicts of interest, none are expected because this study was being conducted solely for scholarly objectives. The researcher made sure that all data, analyses, and interpretations are conveyed with accuracy, integrity, and objectivity if there are chances to share the findings through conferences, research forums, or scholarly journal articles. The findings of the study were solely based on the information gathered and were not be altered to serve any outside objectives. The researcher sought outside assessment of the study's methods, data, analysis, and findings in order to maintaining academic integrity, maintaining credibility and enhancing the larger academic conversation.

Qualification of Researcher: With a master's degree in education with a concentration in Educational Administration, the researcher was exceptionally qualified for this work. With a bachelor's degree, the researcher has received extensive instruction in academic research, data collection, and analysis. Additionally, their knowledge of educational research methodology has grown because of their involvement in conferences, training sessions, seminars, workshops, and research forums. This investigation was made necessary by the researcher's present enrollment in the Thesis Writing course.

Adequacy of Facilities: To ensure a calm setting for students to provide answers without interruption, the researcher administered the tests and questionnaires in the classrooms. Participants were able to concentrate on their answers because the environment was set up to create a relaxed and supportive environment. If someone needs a more private environment, the researcher will collaborate with school administrators to provide a different quiet area. An effective data collection procedure will also be ensured by providing the required tools, such as writing instruments, printed questionnaires, and envelopes for secure collection. When the teachers are filling out the questionnaire, the researcher was ready to answer any questions or concerns they may have.

Community Involvement: Students' participation in this study, especially in the selected school, provides important information about the effects of organizational and instructional practices as well as school leadership. The researcher made sure that the data collection methods and the creation of the study questionnaire are carried out with regard for the participants' customs and cultural sensitivity. Future policies and activities that enhance students' instructional continuity and performance will be guided by the outcomes of this study, which will enhance understanding of the issues, needs, values, and priorities within the educational community.

RESULTS

The data obtained to find out if game-based strategies are beneficial in improving students' performance in Chemistry was examined, interpreted, and discussed in this chapter. The results are arranged in accordance with the specific questions mentioned in Chapter I.

Competency level of the students during the pretest in terms of the control group.

Table 1 displayed the pretest results of control group

Table 1 Pretest Result of the Control Group

Mean	Class Proficiency	Competency Level
9.9	33%	No Mastery

As reflected in the table, the mean score of the control group is 9.9 and the class proficiency of 33%. This performance level indicates that the students have a limited comprehension of the chemistry concepts evaluated in the test, described as the No Mastery competency level.

Competency level of the Experimental group during the pretest

Table 2 displays the pretest results of experimental group.

Table 2

Pretest Result of the Experimental Group

Mean	Class Proficiency	Competency Level
10.05	33.5%	No Mastery

As displayed in the table, mean score was 10.05 and a class proficiency of 33.5. This result falls within the "No Mastery" competency group, suggesting that the student's comprehension of the chemistry being tested is limited.

Competency level of the Control group during the post test

Table 3 presents the competency level of the students in chemistry in the post-test

Table 3

Post-test Result of the Control Group

Mean	Class Proficiency	Competency Level
15.05	50%	Nearing Mastery

As shown in the table, the control group receives a mean score of 15.05 and 50% class competency. This indicates that the students have a moderate comprehension of the chemistry concepts evaluated, placing the group at the "Nearing Mastery" competency level.

Competency level of the Experimental Group during the post-test

Table 4 displays the competency level of the experimental group in the post-test.

Table 4

Post-test Result of the Experimental Group

Mean	Class Proficiency	Competency Level
18.3	61%	Mastery Level

The table shows that the experimental group has a mean score of 18.3 indicating 61% class competency. This indicates that the students have a solid grasp of the chemistry concepts evaluated, placing the group at the "Mastery" competency level.

Significant difference between the pretest scores

Table 5 presents the result of the analysis on the pretest scores of the students.

Table 5 Pretest Results of the Control and Experimental Group

Group	Mean	SD	t- value	p- value	Decision
Control	9.9	3.478			
Experimental	10.05	5.226	-0.107	0.915	Accept Ho;No Significance

An independent samples t-test was used to compare the pretest results for the experimental group (mean = 10.05, SD = 5.226) with the control group (mean = 9.9, SD = 3.478). Prior to the intervention, there is no statistically significant difference between the two groups, according to the t-value of -0.107 and p-value of 0.915.

The null hypothesis (Ho) is accepted since the p-value is higher than 0.05, indicating that both groups began with comparable levels of prior chemistry expertise. This creates a reasonable baseline for assessing the impact of the study's educational strategies.

Difference between the pretest and post-test of the control group

Table 6 presents the paired sample t-test results to determine whether there is a significant difference between the pretest and post-test scores of students in chemistry within the control group.

Table 6 **Pretest and Post-test Result of the Control group**

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Test	**Mean**	**SD**	**t- value**	**p- value**	**Decision**
Pretest	9.9	3.478	-13.59	<.001	Reject Ho;Significant
Posttest	15.05	2.996			

The results of the paired samples t-test, which was used to ascertain if the control group's pretest and post-test scores differed significantly, are shown in the table. Low starting performance and a wide range of student scores before the intervention are indicated by the pretest mean score of 9.9 with a standard deviation of 3.478. The post-test mean is increased to 15.05 with a standard deviation of 2.996 following the instructional time, indicating both an improvement in overall performance and more stable student scores.

In addition, the difference between the pretest and post-test scores is statistically significant at the 0.05 level of significance as reflected in the calculated t-value of -13.59 and a p-value of less than.001. The null hypothesis is rejected since the p-value is significantly less than 0.05. Therefore, there is a significant difference between pretest and post-test scores of the control group.

Difference between the pretest and post-test of the experimental group

Table 7 shows the difference between the pretest and post-test scores of the experimental group.

Table 7 **Pretest and Post-test of the Experimental Group**

Group	Mean	SD	t- value	p- value	Interpretation
Pretest	10.05	3.478	-12.80	<.001	Reject Ho;Significant
Posttest	18.3	2.996			

The results of a paired samples t-test comparing the pretest and post-test scores are displayed in the table. Prior to the intervention, student performance was initially poor, as evidenced by their pretest mean of 10.05 and standard deviation of 3.478. The post-test mean rose to 18.3 with a smaller standard deviation of 2.996 following the instructional period, indicating that students not only performed better overall but also showed more consistent results when compared to the pretest.

Moreover, the difference between the pretest and post-test scores is statistically significant at the 0.05 level of significance based on the calculated t-value of -12.80 and a p-value of less than .001. The null hypothesis is rejected since the p-value is significantly less than 0.05. This indicates that students' performance on the pretest and post-test has significantly improved.

Difference between the post-test scores of the control and experimental group

Table 8 presents the independent samples t-test results to determine whether a significant difference exists between the post-test scores of the control and experimental groups.

Table 8 Posttest Results of the control and experimental group

Group	**Mean**	**SD**	**t- value**	**p- value**	**Interpretation**
Control	15.05	3.478	-2.260	0.030	Reject Ho;Significant
Experimental	18.3	5.226			

As reflected in the table, the experimental group has a mean of 18.3 (SD = 5.226) and the control group has a mean of 15.05 (SD = 3.478). An independent samples t-test produced a p-value of 0.030 and a t-value of -2.260, both of which are below the significance level of 0.05. This implies that there was a statistically significant difference between the experimental and control groups' post-test scores.

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DISCUSSIONS AND CONCLUSION

The results of the study are analyzed and interpreted in this chapter, with an emphasis on how well traditional and game-based learning approaches can improve the chemistry performance of grade 11 students. It highlights the educational significance of the findings, connects them to the research goals, and offers evidence-based conclusions and useful advice for educators and future researchers.

Discussions

Competency level of the students during the pretest in terms of the control group: The pre-test findings for the control group that fell under "No Mastery" show a serious deficiency in fundamental conceptual knowledge, which is a common issue in chemistry education. These gaps go beyond poor results since they make it more difficult for pupils to comprehend, relate to, and apply new ideas. This supports Buell (2024) pointed out that while pupils with little prior knowledge find it difficult to advance, individuals with a stronger starting comprehension make greater learning gains. This implies that students consistently struggle to grasp chemical subjects in the absence of a strong conceptual background.

The result indicated that students' conceptual misunderstandings frequently result from their inability to connect the macroscopic, symbolic, and submicroscopic levels of chemistry. This confirms the study of Rahmawati et al (2022) which revealed that secondary students' incapacity to relate observable events to molecular explanations and symbolic representations is often the cause of low competence and mistakes in diagnostic assessments. The data confirms that pupils' inadequate conceptual knowledge prevents them from engaging meaningfully with exam items.

The present study affirms the work of Talanquer (2026) revealing that beginners frequently rely on educated guess that are in disagreement with scientific explanations, and learners' conceptual frameworks for understanding chemistry events change as they gain knowledge. The author asserts that students' misconceptions endure and restrict their capacity to incorporate original concepts into solid mental models in the absence of focused instructional support to alter these innate frameworks. This is consistent with this study's conclusion that students in the control group, who were exposed to conventional methods, probably retained erroneous or fragmented ideas, making it difficult for them to complete diagnostic tests that gauge deeper comprehension.

The results are closely comparable to the findings of Tümay (2016) and Abenes and Caballes (2020) showing that the low scores imply that students had poor conceptual foundations before they started learning, which made it challenging for them to make connections between macroscopic observations, submicroscopic particle activity, and symbolic representations in chemistry.

Similarly, this incapacity to connect the many levels of chemical representation is a major contributing element to the development of enduring misunderstandings which also aligns to Tümay (2016). This explains why students found it difficult to give accurate responses on the pre-test: without integrated conceptual frameworks, they are unable to apply existing knowledge to new situations or interpret questions meaningfully.

The results mirror the difficulties mentioned by Talanquer (2011), Taber (2013), and Cooper, Underwood, and Hilley (2012) which are evident in the control group's pre-test findings, as "No Mastery" category. The poor performance shows that students' chemistry reasoning is disjointed and based more on unrelated facts than on coherent conceptual frameworks. The claim agrees with Talanquer (2011) that this kind of fragmented reasoning frequently results in repeated errors in chemistry. In the case of the control group, the students' incapacity to correctly respond to numerous pre-test questions indicates that their thinking was not yet structured around basic chemical principles, resulting in mistakes that were both frequent and systematic.

In the same manner, the result is in conformity to the work of Cooper, et al (2012) which research lends confirmation to the idea that students' problems frequently result from their inability to connect symbolic representations to chemical occurrences. Translating between formulas, equations, and actual chemical behavior is necessary for many chemistry ideas. This discrepancy is reflected in the pre-test results of the control group, where students had trouble connecting symbolic representations with the fundamental chemistry concepts, leading to poor comprehension and little mastery.

Competency level of the students during the pretest in terms of experimental group: Similar to other students in the control group, the experimental group's pre-test findings show that students originally showed a low level of comprehension of the chemistry topics under study. This implies that students had trouble understanding basic chemistry principles, which probably had an impact on how well they performed on the diagnostic test. Their poor conceptual basis is reflected in their limited prior knowledge, which makes it challenging for them to interact with new information in a meaningful way.

This result is consistent with Taglorin et al. (2025), who discovered that many students still fall into the "not mastered" group in critical chemistry competences, underscoring the ongoing deficiency of fundamental knowledge in secondary scientific education. It confirms that students frequently approach advanced chemistry courses with inadequate conceptual preparation. The statement also confirms Taber (2013) in his research that low pre-intervention achievement often implies more general difficulties in handling abstract scientific concepts lends more importance to this theory.

Similar to the control group, the experimental group's pre-test results show a low initial level of comprehension in the evaluated chemistry topics. This implies that students typically lacked a firm grasp of basic chemistry principles before the intervention. The present study is in consonance with the research conducted by Chiu and Grove (2021) which revealed that secondary students often struggle to learn chemistry when education is mostly teacher-centered because it restricts possibilities for active involvement, conversation, and hands-on investigation. This same dynamic could be seen in the experimental group's poor pre-test scores in the research. Instead, engaging in interactive processes that promote deeper thinking and concept integration, students were supposed to learn through passive reception.

This supports the notion that students' early mastery levels are influenced by both the learning environment and their prior knowledge. In order for students to develop and retain chemistry concepts rather than merely rely on rote memorization, the results emphasize the necessity of teaching approaches that actively involve learners, such as guided experimentation, cooperative problem-solving, or game-based strategies. By determining this baseline comprehension, the study establishes the requirement and possible effects of the intervention given to the experimental group, confirming that both groups began with comparable difficulties. The result aligns with the study of Byusa et al. (2022), who noted a growing emphasis on learner-centered approaches, such as game-based learning, as a response to students' challenges with traditional teaching methods, are likewise consistent with the low baseline performance of the experimental group. They believe that conceptual frameworks, which pupils frequently lack before training, can be developed with the use of dynamic and captivating teaching strategies.

Competency level of the students in chemistry during the post test in terms of control group: The post-test results for the control group showed that students had a respectable grasp for chemistry principles, falling into the "Nearing Mastery" category. This suggests that additional reinforcement and greater cognitive engagement are required to obtain full mastery, even when learners demonstrated modest improvement from their initial low proficiency. This result is consistent with the findings of Lamidi et al. (2015) who found that students taught using traditional instructional methods frequently attain only partial understanding in comparison to those exposed to more creative or mastery-focused strategies. This suggests that traditional approaches may not be adequate to support full conceptual mastery.

The results also support the findings of Taber (2013) who pointed out that teacher-centered methods can leave students with fragmented knowledge and a superficial comprehension. In a similar vein, the present study confirms Tümay (2016) revealing that learning procedures that do not involve active participation often result in only partial conceptual growth. The result also agrees with of Byusa et al. (2022) that learner-centered, interactive approaches like game-based or participatory methods improve comprehension more successfully than traditional methods.

Both the control and experimental groups' pre-test findings demonstrate the low initial comprehension of the evaluated chemistry concepts, which can be connected to conventional, teacher-centered teaching methods. This aligns with Afari et al. (2013) stating that interactive exercises and game-based learning are examples of instructional methodologies that greatly improve learning experiences and knowledge acquisition. In comparison, there are far less possibilities for students to assimilate concepts and clear up misconceptions when they are essentially passive users of information, as is frequently the case in traditional classrooms.

This point of view further supports Garrison and Akyol (2011) who claimed that when students actively participate in critical thinking, reflection, and self-regulation, deeper learning results. Through these procedures, students can assess their own comprehension, create significant connections, and reorganize misconceptions into precise conceptual frameworks. Applying this to the pre-test results, the experimental group's poor scores before the intervention imply that students' capacity to acquire these higher-order learning skills may have been hampered by insufficient active involvement in earlier training.

In relation to the pre-test results, the students' low initial mastery indicates that they had not yet gotten the benefits of these kinds of hands-on, exploratory learning opportunities. Their inadequate comprehension hindered their capacity to apply ideas or solve chemical puzzles. By encouraging participation, investigation, and self-directed reasoning—all essential for converting disjointed knowledge into cohesive conceptual frameworks—inquiry-based approaches, which mirrors the suggestions of Antonio and Prudente (2024), specifically deal with these deficiencies. This explains why chemistry performance and conceptual understanding can be significantly enhanced by interventions that move students from passive receipt to active inquiry.

Competency level of the students in chemistry during the post test in terms of experimental group: The post-test results for the experimental group showed that students had a solid understanding of chemistry concepts, reaching the "Mastery Level." This indicates that the game-based teaching approach successfully fostered deeper comprehension, improved problem-solving abilities, and promoted active engagement with the subject matter. This result corroborates with Hamari et al. (2016), who found that game-based learning enhances academic performance and engagement by offering prompt feedback, specific objectives, and inspiring challenges that promote involvement and memory retention. Similarly, the result affirms Wouters et al. (2013) stating that serious games are superior to traditional training in terms of helping students learn and retain information, especially when they are accompanied by suitable instructional guidance that helps them comprehend abstract ideas.

The outcome of the present study supports Ke (2016) stressing that encouraging active inquiry and reflection, digital and game-based learning environments improve students' motivation and conceptual understanding. This claim also affirms Connolly et al. (2012) stating that well-made educational games enhance learning outcomes by encouraging persistence, engagement, and conceptual integration. Similarly, interactive and immersive game-based experiences greatly improve cognitive performance and memory in science courses, which mirrors Papastergiou (2010). Additionally, the result of the present study confirms Hussein et al. (2019) noting that digital game-based learning has a lot of promise, especially when it comes to enhancing content knowledge, indicating that these methods can successfully improve students' comprehension of scientific ideas.

Difference of the pretest scores of the students between of control and experimental: The pre-test findings showed that the experimental and control groups had comparable levels of prior knowledge and understanding of the chemistry concepts prior to the intervention. This baseline equivalency guaranteed comparison fairness and offered a strong basis for assessing the impact of the teaching methods. The acceptance of the null hypothesis also implies that any differences found in the post-test are more likely to be related to the intervention than to differences that already existed between the groups.

This result validates the claim of Creswell and Creswell (2018) that pretest equivalency strengthens the internal validity of quantitative experimental research. Similarly, Christensen et al (2014) who asserted that proving group equivalency before an intervention improves internal validity by lowering selection bias and making it possible to more credibly attribute results to the intervention. Furthermore, the result affirms Creswell (2014) emphasizing that determining group equivalence at the beginning of an experiment is crucial for deriving

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trustworthy causal inferences. This viewpoint further supports Ary et al. (2010), who point out that beginning with homogeneous groups enables researchers to isolate the actual impacts of an intervention.
When taken as a whole, these studies demonstrate that baseline equivalency between the experimental and control groups enhances the study's validity and dependability and guarantees that post-test gains may be reliably linked to the teaching strategies used.

Difference between the pretest and post-test of the control group: The post-test results for the control group showed a notable improvement, suggesting that students were able to advance from a lower to a higher level of proficiency and improve their understanding of chemistry concepts. This result confirms previous studies showing that good education, whether conventional or enhanced, can significantly raise academic achievement. In particular, the result affirms Byusa et al. (2022) arguing that teaching methods that encourage conceptual processing and active participation assist students in overcoming early difficulties in learning chemistry. This statement also supports Freeman et al. (2014) who demonstrated that active learning techniques enhance performance in scientific classes when compared to lecture-only methods, indicating that even low levels of participation can improve comprehension and retention.

Moreover, the result is in agreement to Michael (2011), stressing that when students actively engage in the learning process, as opposed to passively listening to lectures, they achieve better conceptual understanding and retain knowledge more effectively. This statement supports the idea that interactive and student-centered teaching methods improve knowledge retention and mastery in STEM fields.

Further, active teaching techniques can significantly enhance student learning over traditional lecture formats, which is demonstrated in the work of Deslauriers et al (2011) that students taught using interactive, research-based instruction showed higher engagement, attendance, and learning outcomes when compared with students in traditional lecture settings. This idea is in conformity to Smith et al (2011) highlighting how student involvement and discussion, when paired with instructor direction, greatly improve conceptual understanding and learning outcomes in science education.

Furthermore, the result is in agreement with Fridolin et al., (2019) asserting that by integrating students in deeper, interactive experiences, active learning methodologies that involve problem-based and collaborative activities improve students' comprehension and application of scientific and mathematical topics. As demonstrated by the significant improvement seen in the control group, these studies collectively confirm that instructional strategies that promote intellectual engagement, active participation, and conceptual processing have a positive impact on student learning.

Difference between the pretest and post-test of the experimental group: The experimental group's post-test performance significantly improved, indicating that the educational intervention, the game-based learning strategy, effectively improved students' understanding, application, and mastery of chemical concepts. This result supports the findings of Hamari et al. (2016), who stated that game-based learning boosts student motivation and engagement—two important elements for better learning outcomes. The significant improvements observed in the experimental group are aligned to Wouters et al. (2013) who confirm that serious games with explicit goals, feedback, and interactive elements are superior to conventional teaching techniques in fostering information acquisition and retention.

These results corroborate with Ke (2016) who concurred that by promoting inquiry and introspection, digital and game-based learning environments improve conceptual comprehension and motivation. The statement affirms Connolly et al. (2012)emphasizing that well-crafted educational games increase accomplishment by encouraging perseverance, engagement, and conceptual integration. Immersion, interactive game-based experiences enhance cognitive function, recall, and the capacity to apply scientific concepts, which affirms Papastergiou (2010).

As demonstrated by the significant difference between pretest and posttest results, these studies collectively demonstrate that the experimental group's use of game-based learning was crucial in encouraging active engagement, enhancing conceptual understanding, and attaining higher competency in chemistry. The result is consistent with those of Li and Tsai (2013), who show that game-based and inquiry-oriented techniques improve understanding, critical thinking, and the transfer of information to new contexts.

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Difference of the post-test scores between the control and experimental group: The decision to reject the null hypothesis suggests that the experimental group's instructional strategy had a significant impact on students' learning. This result conforms to the claim of Tan and Hew (2017) which highlight how interactive learning settings improve conceptual understanding by including students in active cognitive processing and peer interaction, help to better understand this result. The success of the experimental group's performance indicates that the techniques used, like game-based and student-centered activities, gave students the chance to think more deeply about the ideas rather than merely taking in information.

The result also supports the claim of Yang (2021) that engagement in gamified and problem-solving activities is positively linked to enhanced academic performance in science provides more context for the study's findings. The experimental group's better performance indicates that the instructional intervention did more than just impart knowledge; it actively involved students in tasks that called for perseverance, effort, and strategic thinking. When learning chemistry, these components are crucial because students must apply concepts, analyze issues, and work through multi-step solutions.

The result indicates that the intervention certainly motivated students to actively engage in conversations, work together with classmates, and digest information through relevant tasks. These experiences support Tan and Hew (2017) stating that students who are socially and cognitively engaged learn more effectively. The better results in the experimental group suggest that students were able to build their own conceptual knowledge of chemistry through engagement and interaction, both of which are critical for deeper learning.

Furthermore, students' motivation and willingness to actively participate in the learning process may have grown as a result of game-based features like prizes, progress tracking, or competition. This increased level of involvement can result in more time spent on the task and a higher level of cognitive commitment, both of which are essential for understanding difficult chemistry ideas. The statement corroborates with Yang (2021) pointing out that the growth of strategic thinking is very essential to the results. Students were probably forced to prepare, assess, and modify their strategies in order to reach the right answers through problem-solving exercises. By enabling learners to go beyond memorization and toward meaningful application of knowledge, these higher-order thinking processes ultimately improve academic achievement. When taken as a whole, these investigations verified the current conclusion that the experimental group's educational experience produced higher learning gains than conventional methods. This implies that teaching methods that actively include students in the creation of information can more successfully encourage mastery of chemistry concepts.

CONCLUSION

It can be concluded from the study's results that game-based strategies work well for improving chemistry students' performance. From the pretest to the post-test, both the experimental and control groups exhibited notable progress, but the experimental group made more progress and attained a higher degree of mastery. The fairness of the experimental design was validated by the lack of a significant difference in the pretest scores, which verified that the two groups were equivalent at the start of the investigation. Results revealed that there was a significant difference between the two groups' post-test scores. As a result, game-based strategies for learning greatly enhance students' proficiency and academic performance in chemistry.

RECOMMENDATION

The study's conclusions lead to the following suggestions for enhancing chemistry instruction. With an emphasis on the efficient use of game-based strategies, improving student engagement and mastery, and directing future research on interactive teaching approaches:

1. Teachers are urged to include game-based learning techniques into chemistry lessons. Within these exercises, they should employ formative evaluations to track development, give prompt feedback, and correct misunderstandings as they emerge. Furthermore, integrating interactive techniques with conventional instruction can enhance procedural abilities as well as conceptual comprehension, optimizing learning outcomes.

2. School administrators and leaders should offer professional development and training. In order to foster the exchange of best practices and cutting-edge teaching techniques, they should also encourage the adoption of educational technology, request more equipment in the computer laboratories and resources that assist interactive science learning.

3. Students are urged to actively participate in game-based learning activities. In order to improve their problem-solving and higher-order thinking abilities, they should work together with their classmates on interactive projects. They should also use games and simulations as additional resources for practice and reinforcement outside of the classroom.

4. Future researchers are urged to carry out studies with larger and more diverse populations. They should also look into how game-based learning affects knowledge retention, critical thinking, and problem-solving abilities over time, as well as how well it works in other areas like biology, physics, or arithmetic. The best methods for enhancing student learning results can also be found by contrasting various game-based approaches, such as digital versus non-digital or competitive versus collaborative.

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APPENDICES

Test Questionnaire

Appendix D: Test Questionnaire

Pretest/Posttest

Name (Option____________________________Section__________Score: _______

Direction: Read and solve the given problems carefully. Write the letter of your answer in the space provided before each number.

____1. The molar mass of carbon (C) is:

A. 1 g/mol B. 6 g/mol C. 12 g/mol D. 24 g/mol

____2. How many Moles are there in 24 grams carbon?(Molar mass C= 12 g/mol)

A. O.5 mol B. 1 mol C. 2 mol D. 3 mol

____3. What is the mass of 3 moles of water (H_2O)? (Molar mass H_2O= 18 g/mol)

A. 6 g B. 18 g C. 36 g D. 54 g

____4. How many grams are there in 0.5 moles of NaCl? (Molar mass NaCl=58.5)

A. 14.63 g B. 23.4 g C. 29.25 g D. 58.5 g

____5. The number of particles in 1 mole of any substance is approximately:

A. $6.02x10^{20}$ B. $6.02x10^{23}$ C. $6.02x10^{26}$ D.$6.02x10^{29}$

____6. Calculate the molar mass of CO_2. (Atomic masses: C=12, O=16)

A. 12 g/mol B. 28 g/mol C. 44 g/mol D. 48 g/mol

____7. What mass of oxygen gas (O_2) contains 2 moles? (molar mass= 32g/mol)

A. 16 g B. 32 g C. 48 g D. 64 g

____8. How many moles are there in 88 grams of CO2?(Molar mass- 44g/mol)

A. 1 mole B. 2 moles C. 4 moles D. 44 moles

____9. If 36 grams of water contain 2 moles, what is the molar mass of water?

A.9 g/mol B. 12 g/mol C. 18 g/mol D. 36/mol

____10. The mass of 1 mole of aluminum (Al) is:

A. 13 g B. 26 g C. 27 g D. 54 g

____11. How many Valence electron does nitrogen have?

A. 3 B. 5 C. 7 D. 8

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____12. What id the Lewis dot symbol for oxygen?

A. O with 4 dots around it C. O with 8 dots around it

B. O with 6 dots around it D. O with no dots

____13. Which of the following shows the correct Lewis dot structure for hydrogen (H)?

A. H with one dot C. H with 2 dots

B. H with 3 dots D. H with no dots

____14. In the Lewis structure of methane (CH_4), how many shared pairs of electrons are there?

A. 2 B. 3 C. 4 D. 5

____15. What type of bond is represented by a single line between two atoms in a Lewis dot structure?

A. Single covalent bond C. Double covalent bond

B. Ionic Bond D. Hydrogen bond

____16. How many lone pairs of electron in the water molecule (H_2O)?

A. 1 B. 2 C. 3 D. 0

____17. Which molecule is correctly drawn with a triple bond in its lewis structure?

A. CO_2 B. N_2 C. H_2O D. CH_4

___18.What is the total number of valence electrons in ammonia (NH_3)?

A. 6 B. 8 C. 10 D. 12

___19. In a Lewis dot structure, what do dots around an element represent?

A. Nucleus Electron B. Valence electrons C. Core electrons D. Neutrons

____20.What sub atomic particle has a positive charge?

A. Electron B. Proton C. Neutron D. Photon

____21. What is the charge of a neutron?

A. Positive B. Negative C. Neutral D. Variable

____22. Which particle orbits the nucleus of an atom?

A. Proton B. Neutron C. Electron D. Nucleus

____23. The atomic number of an element is equal to the number of:

A. Protons B. Neutrons C. Electrons D. Both A and C in a neutral atom

____24. A neutral atom ha 11 protons and 11 electrons. What is its atomic number?

A. 11 B. 22 C. 10 D. 0

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____25. Calcium-40 has 20 protons. How many neutrons does if have?

A. 20 B. 40 C. 60 D. 80

____26. Isotopes have the same number of protons but different number of:

A. Electrons B. Neutrons C. Protons D. Nuclei

____27. The nucleus of an atom contains:

A. Only protons C. Protons & neutrons B. protons & electrons D. Neutrons and electrons

____28. Which of the following elements ha highest electronegativity?

A. Helium B. Lithium C. Fluorine D. Oxygen

____29. What is a cation?

A. An atom with additional neutrons C. An atom with more than protons

B. An atom with additional neutrons D. A neutral atom

____30. When an atoms gains electron, it becomes:

A. An Isotopes B. An ion C. Cation D. Neutral

Appendix E: **Summary of Validation**

Name of Researcher:**JOY S. GAYUD** Degree Enrolled: **MAED EDAD**

Title of Research: **Enhancing Performance in Chemistry through Game-based Strategies: An Experimental Design**

Items						
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	**Descriptive Rating**
1	4	3	4	4	4	**Excellent**
2	4	3	4	4	4	**Excellent**
3	4	3	4	4	4	**Excellent**
4	4	3	4	4	4	**Excellent**
5	4	3	4	4	4	**Excellent**
6	4	3	4	4	4	**Excellent**
7	4	3	4	4	4	**Excellent**
8	4	3	4	4	4	**Excellent**
9	4	3	4	4	4	**Excellent**
10	4	3	4	4	4	**Excellent**
11	4	3	4	4	4	**Excellent**
12	4	3	4	4	4	**Excellent**
13	4	3	4	4	4	**Excellent**
14	4	3	4	4	4	**Excellent**
15	4	3	4	4	4	**Excellent**
16	4	3	4	4	4	**Excellent**
17	4	3	4	4	4	**Excellent**

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18	4	3	4	4	4	**Excellent**
19	4	3	4	4	4	**Excellent**
20	4	3	4	4	4	**Excellent**
21	4	3	4	4	4	**Excellent**
22	4	3	4	4	4	**Excellent**
23	4	3	4	4	4	**Excellent**
24	4	3	4	4	4	**Excellent**
25	4	3	4	4	4	**Excellent**
26	4	3	4	4	4	**Excellent**
27	4	3	4	4	4	**Excellent**
28	4	3	4	4	4	**Excellent**
29	4	3	4	4	4	**Excellent**
30	4	3	4	4	4	**Excellent**

Panel of Validators:

Rubrics:

5 experts rated 3 or 4 Excellent

4 experts rated 3 or 4-Good

3 experts rated 3 or 4-Fair

2 experts rated 3 or 4-Discard