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Science Gamification on Engagement and Academic Performance: A Compendium of Interactive Tools Basis for Enhancement Program

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Abstract

This study investigated the effect of interactive games on students' engagement and academic achievement in science. Anchored on the Theory of Gamified Learning and supported by Constructivist Learning Theory, the study examined how game-based activities influence behavioral, emotional, and cognitive engagement, as well as science performance. A quantitative quasi-experimental research design using pre-test and post-test procedures was employed. The study involved 39 Grade 11 students from Guindaruhan National High School in Minglanilla, Cebu, with 20 students assigned to the experimental group and 19 students assigned to the control group. The experimental group learned science through interactive games, while the control group received traditional lecture-based instruction. Data were gathered using an adapted student engagement questionnaire, classroom observations, academic evaluations, and a 25-item science test. Means, weighted averages, paired t-tests, and independent samples t-tests were used to analyze the data. Findings revealed that both groups improved in engagement and science achievement after instruction; however, the experimental group obtained higher gains in engagement and examination performance. The experimental group's engagement increased from high to very high, while its science performance improved from low mastery to high mastery. Significant differences between the groups confirmed that interactive games were more effective than traditional instruction in improving engagement and academic achievement. The study supports SDG 4 on Quality Education, SDG 9 on Industry, Innovation and Infrastructure, and SDG 10 on Reduced Inequalities by highlighting innovative, technology-supported, and accessible teaching strategies. Its sustainability impact lies in promoting learner-centered science instruction, improving resource use, and supporting institutional efforts toward more engaging and inclusive education.

Keywords: Academic Achievement, Gamified Learning, Interactive Games, Science Education, Student Engagement, Technology-Based Instruction

1. Introduction

This study examines the effect of interactive games on students' engagement and academic achievement in science among junior high school students. It responds to the continuing need for teaching strategies that promote active learning, motivation, participation, and improved science performance, particularly in contexts where traditional textbook-based instruction remains common. The study is anchored on the Theory of Gamified Learning and supported by Constructivist Learning Theory, emphasizing how game elements, interaction, feedback, problem-solving, and decision-making may improve students' behavioral, emotional, and cognitive engagement. It also considers the local and national challenges affecting Filipino learners, including science performance gaps, resource limitations, teacher preparedness, and access to technology.

1.1 Background of Interactive Games in Junior High School Science Learning

Educational systems continue to evolve in terms of teaching tactics, curriculum, standards, materials, and learning environments. One strategy increasingly considered in modern pedagogy is the use of interactive games, which can provide immersive, engaging, and student-centered learning experiences. Ratinho and Martins (2023) found that gamified-based learning can increase students' motivation and attention, particularly in classroom participation, although its long-term effect may decline if educators and learners depend on it exclusively. In science education, where lessons often involve the environment, biology, chemistry, and other scientific fields, interactive strategies such as experiments, games, tests, and physical activities may strengthen engagement and conceptual understanding. Teaching tactics can influence students' academic outcomes, and gamification-based learning has been shown to produce better results than traditional learning in some contexts, although traditional learning remains more effective than online classes in others (Lampropoulos & Sidiropoulos, 2024). Gamification is also relevant to educational discipline, design principles, and learning environments (Li, Ma, & Shi, 2023). However, teaching methods must be aligned with the subject matter, learning objectives, and classroom context because some studies indicate that traditional methods may be more efficient than innovative approaches in certain conditions (Cordero & Gil-Izquierdo, 2018). Teachers therefore remain central to the learning process, as they are expected to possess the knowledge, skills, and classroom management capabilities necessary to support student learning (Magsucang et al., 2020).

1.2 Interactive Games as a Teaching Strategy in Science Education

Interactive games may be digital or nondigital depending on available resources and teacher preparation, and they allow learners to interact, socialize, and engage with different situations and people (Grace, 2019). These games are connected not only to play but also to development, interaction and technology, user experience, evaluation, and service (Kai et al., 2023). Their implementation requires careful attention to setting, program structure, timeframe, learning skills, and developmental domains (Utami & Crescenzi-Lanna, 2025). Educators therefore need to consider both the learning environment and the students' abilities before integrating games into instruction. Interactive games and serious games both influence motivation, although interactive games are more associated with extrinsic motivation while serious games often influence intrinsic motivation (Ren, Xu, & Liu, 2025). Intrinsic motivation is important for persistent work (Fishbach & Woolley, 2022), while extrinsic motivation can improve engagement, long-lasting motivation, and learning outcomes (Suman, 2023). These insights support the idea that game-based learning may strengthen students' motivation, which can affect their academic performance. Unlike passive learning experiences, such as lectures or reading, interactive games require learners to participate, decide, solve problems, and apply knowledge. Students exposed to interactive games often engage in activities that require critical thinking, risk assessment, and decision-making. Game-based learning combines enjoyable activities with learning outcomes across subjects (Chen et al., 2018), but games must be suitable, understandable, and aligned with instructional objectives to avoid confusion. Recent studies further show that digital games can improve motivation and understanding when properly designed around learning goals. Game-based learning can also increase classroom engagement and participation (Subhash & Cudney, 2018) and positively affect academic performance, particularly in mathematics. However, teachers must plan and guide game use carefully to prevent distraction and confusion. Effective game-based learning should therefore combine enjoyment with meaningful discussion and learning outcomes (Mozelius & Hettiarachchi, 2017). Although game-based learning is not necessarily superior to other methods, it has strong potential to increase motivation and interest (Pho & Dinscore, 2015). It can also support collaborative learning among students, while maintaining interest and commitment through enjoyable activities even when learners experience difficulty or failure (Rowe & Lester, 2015; Taub et al., 2017).

1.3 Student Engagement in Junior High School Science Classes

Student engagement is a key mechanism connecting interactive games with academic outcomes. Engagement includes behavioral, emotional, and cognitive dimensions, although behavioral engagement was found to be the factor most directly affecting academic performance in the study by Çali et al. (2024). Engagement also supports learning, academic performance, critical thinking, creativity, and a positive classroom environment (Thompson, 2023). Compared with traditional teaching, game-based learning can increase student engagement and participation, although traditional learning remains useful and may still be appropriate depending on lesson content, available resources, and student needs (Hafeez, 2022). Globally, student engagement remains a major concern in junior high school education. Engagement is important because it supports academic success and lifelong learning, especially as educators seek ways to sustain students' interest and motivation. It involves emotional, behavioral, and cognitive participation in learning, including enthusiasm, motivation, commitment, classroom participation, attendance, and effort (Bruguera, 2023). Emotional engagement supports motivation and academic outcomes, while cognitive engagement strengthens understanding, critical thinking, and long-term academic success. This is particularly important for junior high school students because they are transitioning from a more structured elementary setting to the greater autonomy and complexity of secondary education. Engagement is influenced by intrinsic motivation, teacher support, peer relationships, and school climate. Positive peer groups can encourage classroom participation (Abenes et al., 2023), while a supportive school environment, strong leadership, adequate resources, and a sense of belonging can enhance engagement. Engagement is strongly related to academic achievement (Li et al., 2023), supports students' transition to higher levels of education, and helps develop study habits, critical thinking, self-regulation, time management, goal setting, and independent learning. Conversely, disengagement may lead to lower achievement, dropout risk, and reduced interest in further education.

1.4 Academic Achievement of Junior High School Students in Science

Academic achievement among junior high school students is influenced by several factors, including financial, psychological, emotional, cognitive, and relational conditions (Brew et al., 2021). Study habits significantly affect students' academic performance (Safi, 2025), and a positive relationship between study habits and academic achievement has also been reported (Elango & Manimozhi, 2021). Academic achievement is further shaped by personal, social, and environmental elements. Support systems, financial resources, and psychological and physical well-being are important for students' school performance. Achievement is commonly measured through grades, test scores, and teacher assessment, which reflect students' ability to learn, think, and perform across subjects (Bouhafa et al., 2023). It is also a predictor of future academic success, college readiness, and professional aspirations. Motivation is another important factor in academic achievement because it drives behavior, action, and desire toward personal, academic, work, family, or other goals.

Students with motivation tend to dedicate time and effort to completing tasks and achieving high scores (Bedalla & Elzouki, 2023). Internally motivated students often show greater persistence, better performance, and higher satisfaction in learning tasks, while motivated learners are more confident and more willing to face academic challenges. Socioeconomic background and parental involvement also affect academic performance, as students with higher socioeconomic status often have better access to educational resources (Basarkod et al., 2023). Learning structure, relevance of content, and classroom climate can also shape motivation. Active and student-centered methods such as project-based, collaborative, and inquiry-based learning can enhance engagement and understanding.

1.5 Local and National Challenges in Science Learning and Instruction

Filipino students continue to face challenges in science, as reflected in international assessments such as the Program for International Student Assessment and the Trends in International Mathematics and Science Study. These challenges are linked to teaching tactics, disengagement, poor learning outcomes, infrastructural limitations, teacher preparedness, and policy constraints. In this context, the Department of Education, school administrators, and teachers need to consider students' needs and the conditions that affect science learning. At the local level, schools in Minglanilla, Cebu face similar challenges. Although some schools have access to computers and multimedia resources, science instruction remains limited when teachers rely mainly on textbook-based methods. This restricts students' exposure to interactive and experiential learning and may widen educational opportunity gaps related to economic and technological access. These conditions provide the basis for investigating whether interactive games can improve students' engagement and achievement in science.

1.6 Theoretical and Conceptual Basis of Gamified Science Learning

This study was anchored on the Theory of Gamified Learning, which explains how game mechanics influence learning behavior and academic achievement. The theory emphasizes that learning does not depend solely on the game itself but on psychological and behavioral processes activated by feedback, points, rewards, difficulty levels, and progression systems. These elements may promote intrinsic motivation, sustain engagement, and create a learning environment that supports meaningful learning. The study was also supported by Constructivist Learning Theory, which emphasizes active participation, problem-solving, and meaningful interaction. Through game-based and interactive activities, learners construct knowledge by exploring, making decisions, applying strategies, and modifying those strategies when needed. In this study, the Theory of Gamified Learning explains how interactive games influence behavioral, emotional, and cognitive engagement, while Constructivist Learning Theory supports the idea that learning improves when students actively participate in science activities. The conceptual flow of the study presents the Theory of Gamified Learning as the theoretical anchor, interactive games as the intervention, student engagement as a key process, and academic achievement as the outcome. The experimental group received interactive games through digital or technological resources designed to promote critical thinking, teamwork, and motivation, while the control group received traditional instruction through textbooks and standard lectures. The study examined how these learning approaches affected participation, attitude, thinking processes, knowledge application, post-test scores, and mean gain. However, it also recognized that academic achievement may not depend solely on teaching strategy because other factors can influence student performance.

1.7 Research Gaps and Rationale for Using Interactive Games in Science

The reviewed literature shows that interactive games can support motivation, engagement, active participation, collaboration, and academic achievement, but their effectiveness depends on proper design, teacher guidance, available resources, learning objectives, and student readiness. Despite these findings, the local implementation of interactive games in science learning remains limited, especially in schools where textbook-based instruction is still common. The study addresses this gap by examining whether interactive games can improve engagement and science achievement among junior high school students and by comparing outcomes between an experimental group using interactive games and a control group using traditional instruction. The review also suggests that interactive games, student engagement, and academic achievement are interconnected. Interactive games may help students enjoy learning, interact with others, challenge their thinking, and test their decision-making. They may also influence psychological, emotional, and cognitive aspects that support students' persistence and performance. Student engagement, in turn, helps learners understand lessons through activities and games while strengthening motivation, performance, and achievement. Thus, interactive games may create a domino effect on engagement, academic performance, and academic achievement throughout students' educational experiences.

1.8 Alignment with Relevant Sustainable Development Goals (SDGs)

This study aligns most directly with SDG 4 – Quality Education because it focuses on improving science learning, student engagement, academic achievement, and instructional practices through interactive games. By examining how game-based learning may increase participation, motivation, understanding, and performance, the study supports efforts to make education more effective, engaging, and responsive to learners' needs. The study also relates to SDG 9 – Industry, Innovation and Infrastructure because it considers the role of digital or technological resources in science instruction. Its focus on interactive games highlights how educational innovation and technology-based learning tools may improve classroom instruction when they are properly designed, guided, and aligned with learning objectives. The study may also connect with SDG 10 – Reduced Inequalities because it considers socio-economic status, access to internet connection, and educational opportunity gaps, particularly in contexts where access to computers, multimedia, and learning resources may vary among students and schools.

1.9 Importance of the Study to Educational, Technological, and Socio-Economic Sustainability

The study contributes to educational sustainability by examining a teaching approach that may strengthen student engagement, motivation, participation, and academic achievement in science. By identifying how interactive games affect learning outcomes, the study may help teachers, school administrators, and education stakeholders improve instructional planning and support more active, learner-centered science education. The study also supports technological and innovation sustainability by exploring the use of digital or technology-based interactive games as instructional tools. Since some schools have access to computers and multimedia but may not fully utilize them in science education, the study provides a basis for understanding how available resources can be used more effectively in teaching. At the same time, it contributes to socio-economic and institutional sustainability by considering access to internet connection, socio-economic status, resource availability, teacher preparedness, and school support as factors related to students' learning opportunities.

1.10 Research Purpose, Questions, and Hypotheses

This study aimed to investigate the effect of interactive games on engagement and academic achievement in science among junior high school students. Specifically, it examined students' profiles in terms of gender, socio-economic status, and access to internet connection; the level of students' engagement in science before and after integrating interactive games in terms of accessibility, enhancement, motivation, objectives, participation, focus and attention, task orientation, and self-regulation; the pre-test and post-test results in science; the mean gain in student engagement and science examination scores; the significant difference in mean gain between the experimental and control groups; and the possible compendium of interactive games relevant to science teaching. The study tested the null hypotheses that there is no significant mean gain from the pre-test to the post-test in terms of students' engagement in science and science examination scores, and that there is no significant mean gain difference between the traditional group and the experimental group in terms of engagement in science and examination scores.

2. Material and methods

2.1 Research Design

The study employed a quantitative quasi-experimental research design using pre-test and post-test procedures. The experimental group was taught science through interactive games, while the control group received traditional instruction through textbook-based teaching, lectures, written activities, and other conventional methods. This design enabled the researcher to compare the effects of the two teaching strategies on students' engagement and academic achievement before and after the intervention. The study also used survey instruments, classroom observations, and academic evaluations, while statistical procedures such as means, independent t-tests, and paired t-tests were applied to interpret the results.

2.2 Locale of the Study

The study was conducted at Guindaruhan National High School, a medium-sized school located in a barangay surrounded by mountains in Minglanilla, Cebu. The school had a total student population of more than 600 students. This setting provided the researcher with direct access to the participants and allowed the study to be conducted within a natural classroom environment.

2.3 Respondents of the Study

The respondents were Grade 11 Senior High School students enrolled at Guindaruhan National High School in Minglanilla, Cebu. Most of the respondents were between 14 and 18 years old and came from different socioeconomic backgrounds, levels of academic capability, and levels of learning engagement. Two sections were involved in the study, which allowed the researcher to divide the respondents into an experimental group and a control group. The study also considered factors such as gender, learning preferences, and availability of resources in examining how interactive games affected students' academic performance and engagement.

2.4 Sample and Sampling Procedure

Random cluster sampling was used to determine the sample of the study. Two Grade 11 sections from Guindaruhan National High School were selected and assigned as the experimental and control groups. The experimental group consisted of 20 students who learned science through interactive games, while the control group consisted of approximately 19 students who learned through traditional teaching methods, resulting in a total sample size of 39 students. The procedures were conducted in a natural classroom setting to obtain genuine and contextually relevant findings.

2.5 Research Instrument

The study used an adapted survey questionnaire from the research study entitled "Game-Based Applications to Enhance Students' Engagement and Performance," conducted by Razhel De Jesus Travinio and Marie Ann Salvador Gonzales in 2022 and published in the International Journal of Research Publications. The original study examined the effects of game-based applications on the engagement and performance of Grade 9 students at Looc Integrated School, Calamba City, during the School Year 2021–2022. The questionnaire assessed student engagement across several domains, including accessibility, enhancement, motivation, objectives, participation, attitude toward games, focus and attention, task orientation, and self-regulation. These domains were relevant to the present study because it also examined student engagement in relation to academic performance. The instrument was adapted for science education while maintaining its original structure to support the validity and reliability of the study. A Likert scale was used to gather quantifiable responses, with values ranging from Strongly Agree to Strongly Disagree. The scale included 4.21–5.00 for Strongly Agree, 3.41–4.20 for Agree, 2.61–3.40 for Fair, 1.81–2.60 for Disagree, and 1.01–1.80 for Strongly Disagree.

2.6 Data Gathering Procedure

The data gathering procedure was conducted in three stages: the preliminary procedure, the actual conduct of the study, and the post-gathering procedure. Before the implementation, the researcher informed the school principal about the study's objectives, purpose, methods, and ethical safeguards. Approval was secured from the principal, and consent was obtained from the parents and guardians. The researcher also assured them that the study was academic in nature and that the students' information would remain confidential. The study was conducted during the students' regular class periods because the researcher was also their educator. This allowed the intervention to be implemented naturally without making students feel pressured or aware of the study's objectives. During the actual conduct, the two Grade 11 sections studied the Earth and Life Science topic "The Earth Subsystems and the Minerals." The experimental group learned through interactive game-based activities, while the control group learned through conventional lecture-based instruction. The experimental group participated in activities such as the Mineral Mystery Spin, Mineral Mystery Box Game, Wordwall Quiz Show, and Mineral Detective Case File. These activities involved mineral identification, group discussion, clues, quizzes, and application tasks using resources such as mineral samples, interactive platforms, a wheel spinner, television, laptop, and PowerPoint slides. In contrast, the traditional group learned through motivation questions, lecture-discussion, board work, oral questioning, and worksheet matching exercises using resources such as the chalkboard, printed mineral charts, worksheets, and mineral samples when available. Both groups completed a paper-based 25-item post-test. After the intervention, the researcher administered the post-test and final survey to assess students' academic achievement and engagement. Confidentiality was maintained throughout the process, and the researcher controlled external factors as much as possible to minimize bias. The same implementation period was applied to both groups, and the gathered data were used to support the research problem.

2.7 Data Analysis Techniques

The study used descriptive statistical analysis and t-test procedures to analyze the data. Frequency and percentage were used to describe the respondents' demographic profile. Weighted averages were computed to evaluate students' engagement and academic performance, while deviations were calculated to determine differences between traditional teaching methods and game-based learning. To test the research hypotheses, the independent samples t-test was used to determine whether there were significant differences between the experimental and control groups in terms of engagement and academic performance. The paired samples t-test was used to examine whether there was a relationship between students' demographic characteristics and their level of involvement or success in science.

2.8 Ethical Considerations

This study followed the ethical principles outlined in the Declaration of Helsinki to protect the welfare of the participants. Ethical approval was obtained from the Research and Ethics Committee of the University of the Visayas with Reference No. 20250293, dated 07 July 2025. The study involved senior high school students from Guindaruhan National High School in Minglanilla, Cebu. Before data collection, written informed consent was secured from the school administrator, and assent forms were obtained from the student participants to confirm voluntary participation. Confidentiality and privacy were maintained by anonymizing all collected data and using them strictly for academic purposes. The participants' identities were kept undisclosed, and responses were accessible only to the research team. The data were securely stored and properly disposed of after the study was completed. The study did not pose physical, psychological, or social risks because the interactive games were conducted within regular academic schedules. No financial incentives were provided, and participants were informed that they could withdraw at any stage without consequences. The researchers declared no conflict of interest, and the findings were reported objectively to maintain academic integrity and transparency.

3. Results and Discussion

3.1 Profile of the Senior High School Students

3.1.1 Demographic Characteristics of the Respondents

The respondents were 39 Grade 11 students, composed of 19 students in the traditional group and 20 students in the experimental group. In terms of gender, 20 students were male, representing 51%, while 19 were female, representing 49%. Most respondents were aged 16–17 years old, comprising 77% of the total population, while 13% were aged 14–15 and 10% were 18 years old and above. For previous academic performance, most students belonged to the 81–86 grade range at 57%, followed by the 75–80 and 87–92 ranges at 20% each, while only 3% obtained grades between 93–98. No respondent had a grade below 74. The profile shows that the respondents were almost equally distributed by gender and mostly belonged to the expected age range for senior high school. Their previous academic performance also indicated generally acceptable academic standing, with most students falling within the satisfactory range. This background provided a useful basis for interpreting the engagement and achievement outcomes of both the traditional and experimental groups.

3.2 Student Engagement Before and After Instruction

3.2.1 Engagement of the Experimental Group After Interactive Games

Before the integration of interactive games, the experimental group showed high engagement across all domains, with an overall mean of 3.88 and a standard deviation of 0.43. After the use of interactive games, the overall engagement increased to a very high level, with a mean of 4.58 and a standard deviation of 0.23. Accessibility increased from 4.13 to 4.94, enhancement from 3.79 to 4.45, motivation from 3.97 to 4.78, objectives from 3.81 to 4.41, participation from 3.84 to 4.71, attitude from 3.94 to 4.72, focus and attention from 3.87 to 4.52, task orientation from 3.87 to 4.45, and self-regulation from 3.68 to 4.22. The results indicate that interactive games improved students' engagement in science, particularly in accessibility, motivation, participation, attitude, and focus. The movement from high to very high engagement suggests that gamified instruction made the learning process more interactive, motivating, and engaging for the students. This also implies that interactive games helped students participate more actively and sustain their attention during science learning activities.

3.2.2 Engagement of the Traditional Group After Lecture-Based Instruction

The traditional group also showed high engagement before and after instruction, but the increase was smaller compared with the experimental group. The overall mean increased from 3.58 before lecture instruction to 3.76 after instruction. Accessibility increased from 3.62 to 3.86, enhancement from 3.63 to 3.84, motivation from 3.56 to 3.73, objectives from 3.63 to 3.75, participation from 3.57 to 3.72, attitude from 3.68 to 3.78, focus and attention from 3.49 to 3.71, task orientation from 3.58 to 3.77, and self-regulation from 3.49 to 3.71. All domains remained within the high level. The results show that traditional instruction also contributed to student engagement, but the improvement was limited. Since the interpretation remained high before and after the lecture-based approach, the findings suggest that conventional teaching can support learning engagement but may not produce the same level of increase as interactive games. This implies that traditional instruction remains useful, but its impact on engagement may be strengthened when combined with more interactive strategies.

3.3 Mean Gain in Student Engagement

3.3.1 Engagement Gains of the Traditional and Experimental Groups

The traditional group increased from a mean engagement score of 3.58 before instruction to 3.76 after instruction, producing a mean gain of 0.18. The computed t-value of 2.45 and p-value of .012 showed a significant improvement. Meanwhile, the experimental group increased from 3.88 before the intervention to 4.58 after the intervention, producing a higher mean gain of 0.70. The computed t-value of 4.49 and p-value of .001 also showed a significant improvement. The findings show that both instructional approaches improved student engagement, but the experimental group had a substantially higher gain. This suggests that gamified instruction was more effective in promoting engagement than the traditional method. The result emphasizes the value of interactive and technology-based strategies in creating a more motivating and participatory science learning environment.

3.4 Science Examination Performance

3.4.1 Pre-Test and Post-Test Performance in Science

The traditional group obtained a pre-test mean score of 12.68 with a standard deviation of 3.45, interpreted as low mastery, and a post-test mean score of 18.53 with a standard deviation of 4.20, interpreted as moderate mastery. The experimental group obtained a pre-test mean score of 12.15 with a standard deviation of 2.78, also interpreted as low mastery, and a post-test mean score of 20.45 with a standard deviation of 3.06, interpreted as high mastery. The results indicate that both groups improved after instruction, but the experimental group reached a higher level of mastery. While the traditional group moved from low mastery to moderate mastery, the experimental group moved from low mastery to high mastery. This suggests that interactive games may have contributed more strongly to students' understanding and retention of science concepts.

3.4.2 Mean Gain in Science Examination Scores

The traditional group increased from a pre-test mean of 12.68 to a post-test mean of 18.53, resulting in a mean gain of 5.85. The t-value of 6.98 and p-value of .001 showed a significant improvement in performance. The experimental group increased from a pre-test mean of 12.15 to a post-test mean of 20.45, resulting in a higher mean gain of 8.30. The t-value of 12.71 and p-value of .001 also showed a significant improvement. The findings show that both approaches improved science examination performance, but gamified instruction produced greater academic gains. The higher mean gain of the experimental group suggests that interactive games were more effective in improving students' achievement in science. This supports the use of engaging and innovative instructional strategies to strengthen learning outcomes.

3.5 Significant Difference Between the Traditional and Experimental Groups

3.5.1 Difference in Student Engagement Mean Gain

The difference in student engagement mean gain between the traditional and experimental groups was significant. The traditional group obtained a mean gain of 0.18, while the experimental group obtained a mean gain of 0.70, resulting in a mean difference of 0.52. The result showed $U=18.0$, $df=37.0$, and $p< .001$, which led to the rejection of the null hypothesis. The result indicates that the experimental group improved significantly more than the traditional group in terms of student engagement. This suggests that the use of interactive games had a stronger effect on students' engagement than lecture-based instruction. The finding supports the idea that gamified learning can increase students' participation, attention, motivation, and interest in science learning.

3.5.2 Difference in Science Examination Mean Gain

The difference in science examination mean gain between the two groups was also significant. The traditional group obtained a mean gain of 5.85, while the experimental group obtained a mean gain of 8.30, producing a mean difference of 2.45. The result showed $t=2.27$, $df=37.0$, and $p=0.029$, which also led to the rejection of the null hypothesis. The result shows that the experimental group achieved greater improvement in science examination scores than the traditional group. This means that interactive games were more effective in enhancing academic achievement in science. The finding also suggests that instructional strategies involving interaction, competition, feedback, and active participation may help students understand science concepts more effectively.

3.6 Compendium of Interactive Games for Science Teaching

3.6.1 Digital and Non-Digital Interactive Games

The study identified a compendium of interactive games that may be used in science teaching. The online interactive games included Blooket, Kahoot!, Wordwall, and Quizziz, which were used to support quizzes, review activities, formative checks, practice, and student-level assessment. These platforms used game mechanics such as points, leaderboards, speed-based scoring, power-ups, matching activities, quizzes, and self-paced responses. The offline games included Mystery Box Risk/Reward Quiz, 4 Pics 1 Word, Do, Don't, Like, Love Spinning Wheel, Family Feud, Shopee Delivery Game Mechanics, and Deal or No Deal. These games involved strategy, teamwork, visual analysis, sequencing, decision-making, risk assessment, and content recall. The compendium shows that interactive games can be adapted to different branches of science, including biology, chemistry, physics, and earth science. These tools may help teachers create more dynamic learning environments by combining enjoyment, competition, collaboration, and academic content. The inclusion of both online and offline games also suggests that gamified learning can be implemented even in settings with different levels of technological access.

3.7 Summary of Findings

The findings revealed that both the traditional and experimental groups improved in engagement and academic achievement after instruction. However, the experimental group exposed to gamified learning strategies obtained higher mean gains in both student engagement and science examination performance. The statistical results also showed significant differences between the groups, confirming that the gamified instructional approach was more effective than the traditional teaching method in improving students' engagement and academic achievement in science. The overall results suggest that interactive games positively influenced students' learning outcomes by increasing engagement, motivation, participation, and mastery of science concepts. While traditional instruction still produced significant improvement, the stronger outcomes of the experimental group highlight the potential of gamified instruction as an effective strategy for science education.

4. Conclusion & Recommendations

The study concluded that integrating gamification into science instruction improved students' engagement and academic performance. The experimental group exposed to interactive games showed higher participation, stronger interest, and better academic outcomes than the group taught through traditional methods. The compendium of interactive tools served as a research-based framework for enhancing science instruction by promoting learner-centered, engaging, and innovative classroom practices. Overall, the findings emphasized the value of gamified learning as an effective pedagogical approach that supports students' comprehension, motivation, and active participation in science.

Science teachers are encouraged to integrate interactive games and gamified strategies into classroom instruction to promote students' motivation, participation, and interest while reducing boredom during lessons. School administrators should provide institutional, technical, and resource support to help teachers implement gamified learning effectively. Curriculum developers may also incorporate interactive and inquiry-based science activities aligned with 21st-century learning competencies, while future researchers may examine the long-term effects of gamification across other subjects, grade levels, game types, digital platforms, and comparisons between online and offline interactive games.

The study was limited to the use of gamified learning in science instruction and focused on the comparison between students exposed to interactive games and those taught through traditional methods. While the findings showed positive effects on engagement and academic performance, the text indicates that challenges may occur in implementing games and responding to tasks. Further studies are needed to determine the long-term effects of gamification and to examine its applicability across other subjects, grade levels, learning contexts, and types of interactive games.

Compliance with ethical standards

The study followed the ethical principles outlined in the Declaration of Helsinki to protect the welfare, privacy, and confidentiality of the participants. The research involved Grade 11 senior high school students from Guindaruhan National High School in Minglanilla, Cebu, and was conducted within regular academic schedules. All collected data were anonymized, used strictly for academic purposes, securely stored, and properly disposed of after the completion of the study. Participants' identities were kept undisclosed, responses were accessible only to the research team, and no physical, psychological, or social risks or financial incentives were involved.

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