Enhancing Student Analytical Thinking in Geometry among Grade 8 Learners Using the Number Chain Game

Jemard C. Quipit[1], Virginia S. Aninao[2], Genelyn R. Baluyos[3]

[1,3]College of Education, Misamis University

[2]Mathematics Department, Labo National High School

DOI: https://doi.org/10.51584/IJRIAS.2025.100800187

Received: 02 September 2025; Accepted: 08 September 2025; Published: 07 October 2025

ABSTRACT

This action research was done in the classroom to address the low analytical thinking of Grade 8 students in geometry. It investigated whether the Number Chain Game can be used as a strategy to improve students' problem-solving and reasoning skills in geometry. Pre-test and post-test designs were employed to determine the twenty-seven Grade 8 students' analytical thinking prior to and following the game intervention. Findings revealed that the students' performance improved. Prior to the intervention, all students were categorized as "Did Not Meet Expectations," but after playing the Number Chain Game, most were at the level of "Outstanding." According to statistical validation using a paired samples t-test, pupils' capability to engage in analytical thinking improved dramatically. The results indicate that game-based learning techniques like the Number Chain Game can help students develop a love for mathematics and analytical thinking. Educators are advised to incorporate such interactive methods in their practice to support more robust conceptual understanding and critical thinking abilities in geometry.

Keywords: analytical thinking, critical thinking, number chain game, problem-solving skills.

CONTEXT AND RATIONALE

Students who possess analytical thinking are able to answer complex mathematical problems and use logical reasoning in a variety of contexts. In geometry, analytical thinking is essential in the comprehension of spatial relationships, formulating conjectures, and building proofs. Nonetheless, most students struggle to develop analytical skills, leading to a poor understanding of geometric concepts and difficulty solving higher-order thinking questions. Considering the importance of this skill within mathematics and the wider applications across STEM disciplines, it is vital to investigate fruitful teaching methods capable of improving analytical thinking among geometry students (Lo & Hew, 2021).

Although logical reasoning and application of geometric rules to problem-solving activities are essential in mathematics, research has proven that students are usually challenged when it comes to reasoning logically and applying geometric principles to problem-solving activities. The conventional teaching technique, which revolves around direct guidance and memorization, might prove inadequate in supporting higher-order cognitive skills (Ramli et al., 2022). A significant number of Grade 8 students exhibit incompetence in establishing the interconnection of geometric concepts to the detriment of solving problems based on analytical thought (Moon & Ke, 2020). Some educational methods have been pursued in an effort to enhance student involvement and mathematics problem-solving competence. Game-based learning has proven to be a promising method, with studies showing its effectiveness in enhancing students' cognitive involvement, problem-solving abilities, and motivation (Karakoç et al., 2022). Both traditional and digital forms of game-based learning are shown to improve mathematics skills and self-confidence in learners (Ramli et al., 2022). Research indicates that organized and interactive game-based learning not only fosters higher-order thinking but also sharpens critical thinking skills in mathematics (Tangkui & Keong, 2020).

Due to a lack of engaging resources and opportunities, students in the eighth grade encounter difficulties in analytical thinking related to geometry (Maryana et al., 2024). Not much is known about the potential of game-based learning to develop analytical thinking skills in geometry. However, its importance in teaching math is well-documented, to say the least. Therefore, this study aims to fill the gap by implementing the game-based learning strategy, the Number Chain, to enhance students' ability to think and solve problems concerning geometric concepts.

Numerous studies support the idea that game-based learning is a valuable strategy for enhancing the motivation and academic performance of students in mathematics. Game-based exercises not only improve motivation but also support the student's ability to foster higher-order thinking and problem-solving (Bueno et al., 2024). Research on the applicability of gamification in mathematics learning has demonstrated the ability of students to harness more sophisticated concepts (Maryana et al., 2024). Given these factors, the use of game-based approaches such as the Number Chain can be helpful in addressing the students' analytical geometry problems.

As far as the use of Game-Based Learning (GBL) in geometry is concerned, the scholar has uncovered some gaps in the prior GBL research. Prior research overlooked the impact of non-digital games, like the Number Chain game, in promoting higher-order thought processes within these concepts, in light of the increasing support for GBL in mathematics education. This addresses a number of gaps, including the impact of these games on critical thinking, problem-solving, and collaboration skills, which are increasingly drawing attention from multidisciplinary research (Yusof & Shahrill, 2021). To comprehend the reasons for the lack of attention such innovative methods receive in geometry classes, additional attention should, however, be placed on the Number Chain game and its potential to enhance analytical thinking (Miles, 2017).

The objective of this action research project is to assess the extent to which the Number Chain aids eighth-grade geometry learners in developing their critical thinking skills. The study aims to determine whether applying this game-based learning process enhances students' ability to understand geometric relationships, develop sound arguments, and address higher-order thinking issues. This research aims to give an insight into creative teaching approaches that can raise students' interest and problem-solving skills in mathematics through an examination of the effect of the Number Chain (Kartika et al., 2023).

Strategy

Number Chain Game is an interactive game-based learning tool designed to help eighth graders understand critical geometric concepts, particularly during the last quarter of their study. This approach aligns with studies that further indicate how game-based learning helps improve learning outcomes, student engagement, and cognitive abilities (Moon & Ke, 2020). Through cooperative learning and application in real life, the plan encouraged active involvement of students and improved concept comprehension.

The game started with the setup phase, during which number cards corresponding to varying side lengths and angle measures were given to students, but they were instructed not to reveal their numbers. The cards were fixed to their foreheads by headbands or tape to encourage inquiry learning and peer support. Students subsequently traveled around the room to create groups of three, working together to see if their three numbers could make a valid triangle or meet other geometric requirements, like parallel lines, perpendicular bisectors, and congruence tests, to engage cognitive activity (Ramli et al., 2022). Each group applied geometric theorems, such as the Triangle Inequality Theorem or the Pythagorean Theorem, based on the provided values. If the condition was met, the class yelled a designated keyword (e.g., Triangle! or Parallel!). In case the condition was not met, students conversed and reformed into new groups, practicing procedural knowledge application (Pan & Ke, 2023). Valid groups shared their results with the class, describing how the theorem worked for their numbers, and groups that were unable to create a valid figure discussed why their numbers did not work, improving metacognition and problem-solving abilities (Tapia-Nunez et al., 2021).

A class discussion was then conducted, inquiring why some groups worked and others did not, which solidified conceptual understanding of geometric relationships. The educator then related these ideas to actual applications, including engineering, architecture, and computer graphics, to facilitate contextual learning (Tangkui & Keong, 2020). Game-based learning (GBL) principles, which have been shown to improve mathematical competency,

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

motivation, and engagement, served as the foundation for this strategy (Letsa-Agbozo et al., 2023). Through the integration of collaboration, inquiry-based learning, and practical applications, the Number Chain Game successfully facilitated the establishment of higher-order thinking abilities and mathematical reasoning (Gómez Niño et al., 2024). Its long-term effect on student retention and self-efficacy in math education should be further investigated in future research.

Action Research Questions

Through the use of the Number Chain Game, this action research seeks to improve the analytical thinking of eighth-grade pupils in a public school in Misamis Occidental. This study aims explicitly to respond to the following queries:

1. What is the level of students' analytical thinking in geometry before the implementation of the Number Chain Game?

2. What is the level of students' analytical thinking in geometry after the implementation of the Number Chain Game?

3. Is there a significant difference in students' analytical thinking in geometry before and after the implementation of the Number Chain Game?

Research Design

The purpose of this action research is to enhance eighth-grade students' critical thinking and geometry engagement by utilizing the Number Chain Game. The study will evaluate students' critical thinking abilities both before and after the intervention using a pre-test and post-test design (Statology, 2020). Additionally, it will provide quantitative data to evaluate the effectiveness of the game-based learning approach (Fiveable, n.d.). This study aims to provide a comprehensive understanding of the Number Chain Game's impact on geometry students' critical thinking skills by examining the findings. This format is suitable since it allows for data triangulation, leading to a more comprehensive and reliable analysis of the Number Chain Game's impact on student outcomes.

Site

Through the Number Chain Game, this action research design aims to enhance students' analytical thinking in geometry classes using a pre- and post-test methodology. In order to assess the effectiveness of the Number Chain Game, researchers will assess students' analytical thinking abilities both before and after the intervention. Students in Grade 8 at a public secondary school in Misamis Occidental, which serves students from a range of backgrounds in Grades 7 through 12, will participate in the study.

Respondents

As junior high school respondents, twenty-seven Grade 8 students from one section of a public secondary school in Misamis Occidental, which educates students from diverse backgrounds in Grades 7 through 12, took part in the study. Purposive sampling was used to select the respondents who met three requirements: they had to be enrolled in Grade 8 for the 2024–2025 academic year, perform poorly academically, and be willing to take part in the study. By contrasting students' analytical thinking before and after the intervention, the study offers quantitative data to assess the efficacy of the Number Chain Game.

Instruments

The researcher will gather information using the following research instruments:

Geometry Test

The research tool was a 40-item multiple-choice questionnaire that was adjusted to match the fourth quarter's content for Mathematics 8. The test's validity was assessed by the principal, research adviser, school head, and cooperating teacher. Pilot testing was conducted on a sample of students who were not involved in the main study in order to evaluate the instrument's reliability. The researcher ensured that the test had a Cronbach's Alpha between 0.7 and 1.0 in order to show adequate reliability. This tool was used to assess how the Number Chain Game impacted the students' capacity for analytical geometry thought both before and after the test.

The following scale was used to evaluate the test performance.

Scores	Grade Equivalent	Interpretation
34-40	90-100	Outstanding
31-33	85-89	Very Satisfactory
28-30	80-84	Satisfactory
24-27	75-79	Fairly Satisfactory
1-23	Below 74	Did not meet expectations

Lesson Plan

The researcher developed a lesson plan to help students better understand key geometric concepts. The cooperating teacher thoroughly reviewed the lesson plan before deployment, and the researcher made the necessary adjustments. The lesson was then taught to Grade 8 students at a public high school in Misamis Occidental between February and March of the 2024–2025 school year.

Data Collection & Procedure

Pre-Implementation Phase

Following approval by the dean of the College of Education, the researcher proceeded to request permission to conduct the study from the principal, the superintendent of the Schools Division, and the cooperating teacher. Data collection did not begin until all necessary permits were obtained. The researcher also obtained parents' and students' informed consent to ensure that participants were aware of the purpose of the study, that their participation was voluntary, and that they could stop at any time without facing any repercussions. At this stage, the teacher's lesson plans and PowerPoint presentations were followed in creating assessments and activities that aligned with the curriculum and learning objectives.

Implementation Phase

After obtaining the required permissions and approvals, the researcher will then embark on the implementation phase. The research will be carried out in collaboration with the cooperating teacher to ensure that it is in sync with the planned lesson schedules and instructional methods. Data collection will begin through the administration of assessments, activities, and observations as scheduled, making sure that they comply with the planned curriculum and learning goals.

The researcher conducted classroom interactions, incorporating prepared instructional materials such as PowerPoint presentations and hands-on activities to promote student participation. Respondents' voluntary participation and confidentiality were ensured by strict adherence to ethical principles throughout the process. Any adjustments required during implementation were made in consultation with the cooperating teacher to maintain the effectiveness of the study while preserving the natural flow of the teaching-learning process.

Post-Implementation Phase

After the implementation phase was completed, the researcher carried out the post-implementation activities. The gathered data were organized, analyzed, and interpreted in order to evaluate the degree of student participation and the efficacy of the teaching strategies. The researcher maintained the anonymity of all collected data and validated findings by speaking with the cooperating teacher and other pertinent parties.

A detailed analysis of student performance, feedback, and class participation was used to assess the intervention's effectiveness. By recording the observations and insights of both the researcher and the cooperating teacher, an integrated conclusion of the study's findings was presented.

Lastly, a report of the findings, conclusions, and recommendations was submitted. This report was presented to the cooperating teacher, school administrators, and other interested stakeholders to offer constructive input for future instructional enhancements. When needed, follow-up discussions or presentations were undertaken to share significant findings and propose best practices for improving the teaching and learning process.

Ethical Considerations

Creswell (2005) emphasized the importance of conducting research in an ethical way, which may include treating respondents with dignity, supplying accurate and thorough data, or considering other factors. As part of their ethical practice, the researchers thoroughly briefed participants on the Data Privacy Act of 2012. Ethical researchers must lead good, relevant research. Therefore, for research initiatives to be successful, the researcher must be aware of ethical considerations.

Before the study began, permission from the College of Education was acquired. Letters requesting consent to participate in the study were sent to the respondents. Participants were given guarantees that confidentiality would be strictly adhered to in the gathering, processing, and presentation of data. For instance, the names were changed to preserve the privacy of the individuals in case the information had to be kept secret. This procedure ensured that research involving human subjects would be conducted securely and morally.

Data Analysis

Minitab software was used with the following statistical tools:

Both frequency and percentage. These were used to compare geometry students' analytical thinking abilities before and after the Number Chain Game was implemented.

Mean and standard deviation. These were used to compare geometry students' analytical thinking abilities before and after the Number Chain Game was implemented.

Paired T-Test. This tool will be used to examine the significant variations in geometry students' analytical thinking before and after the Number Chain Game was introduced.

RESULTS AND DISCUSSION

Students in Grade 8 showed a significant improvement in their awareness and comprehension of geometrical analytical thinking when they played the Number Chain Game. This section presents and analyzes the results of comparing the learners' pre-test and post-test scores. The data collected provided teachers with valuable feedback for enhancing their math teaching techniques as well as insightful information about the strategy's effectiveness.

Level of students' analytical thinking in geometry before the implementation of the Number Chain Game

Table 1 shows the geometry students' analytical thinking abilities prior to the introduction of the Number Chain Game. All 27 students (100%) received a mean score of 13.11, which is significantly lower than the minimal satisfactory standard of 24. None of the students received "Fairly Satisfactory," "Satisfactory," "Very Satisfactory," or "Outstanding." It demonstrates the wide variations in students' analytical thinking, underscoring the pressing need for a geometry intervention like the Number Chain Game.

The findings in Table 1 concur with previous research indicating that students perform poorly in analytical thinking in geometry because they lack interactive and reasoning-based teaching. Students do not effectively relate geometric ideas and employ logical reasoning while solving problems (Moon & Ke, 2020). It is attributed to conventional pedagogies centered on memorization rather than critical thinking (Ramli et al., 2022). Since game-based learning is not being used to improve analytical thinking in geometry, the Number Chain Game and other innovative techniques are necessary, given the 100% failure rate in expectation achievement (Maryana et al., 2024).

The findings imply a strong need to replace traditional teaching with more interactive approaches. The students' low analytical thinking skills suggest that current methods are ineffective in developing higher-order reasoning in geometry. It highlights how important it is to employ strategies like the Number Chain Game to enhance students' critical thinking, problem-solving, and engagement.

Table 1. Level of students' analytical thinking in geometry before the implementation of the Number Chain Game

Performance	Frequency	Percentage
Outstanding	-	-
Very Satisfactory	-	-
Satisfactory	-	-
Fairly Satisfactory	-	-
Did not meet the Expectation	27	100
Overall Performance	13.11 – Did not Meet the Expectation	

Note: Performance Scale: 34-40(Outstanding); 31-33 (Very Satisfactory); 28 30(Satisfactory); 24-27 (Fairly Satisfactory); 1-23 (Did not Meet Expectation)

Level of students' analytical thinking in geometry after the implementation of the Number Chain Game

Table 2 shows the students' degree of analytical geometry thinking following their use of the Number Chain Game. The results demonstrate a high degree of improvement, with students (n = 17, 62.96%) scoring at the "Outstanding" level, students (n = 7, 25.93%) scoring at the "Very Satisfactory" level, and students (n = 3, 11.11%) scoring at the "Satisfactory" level. No student's score fell below the lower performance thresholds. With a mean score of 34.89, the class performance is at the "Outstanding" level, demonstrating the tremendous success of the intervention.

Evidence showing that game-based learning is effective in increasing higher-order thinking, motivation, and problem-solving abilities is the basis for the noteworthy percentage of students (62.96%) who scored an Outstanding level of analytical thinking after playing the Number Chain Game (Ramli et al., 2022). Literature emphasizes that conventional techniques are inadequate to cultivate analytical ability, whereas cooperative games such as the Number Chain enhance collaboration, metacognition, and understanding at the conceptual level (Maryana et al., 2024). The approach is in alignment with the literature that supports game-based learning as a potent vehicle for geometry teaching.

These findings imply that the Number Chain Game had a significant influence on students' analytical thinking in geometry. After going from 100% underachievement, all students reached adequate or higher levels, indicating that game-based learning promotes critical thinking, active engagement, and a deeper understanding of geometric concepts.

Table 2. Level of students' analytical thinking in geometry after the implementation of the Number Chain Game

Performance	Frequency	Percentage
Outstanding	17	62.96
Very Satisfactory	7	25.93
Satisfactory	3	11.11
Fairly Satisfactory	-	-
Did not meet the Expectation	-	-
Overall Performance	34.89 - Outstanding	

Note: Performance Scale: 34-40(Outstanding); 31-33 (Very Satisfactory); 28-30(Satisfactory); 24-27 (Fairly Satisfactory); 1-23 (Did not Meet Expectation)

Significant difference in students' analytical thinking in geometry before and after the implementation of the Number Chain Game

Table 3 summarizes the findings of a paired samples t-test that was used to assess whether there was a significant difference between the analytical thinking of eighth-grade geometry students before and after they used the Number Chain Game. The test identifies whether the same set of students differed in pre- and post-intervention mean scores. The comparison indicated a statistically significant difference in students' analytical thinking in geometry prior to ($M = 13.11$, $SD = 3.94$) and subsequent to ($M = 34.89$, $SD = 3.14$) the use of the Number Chain Game, $t(df) = 27.80$, $p = .000$.

The findings show that students' critical thinking skills considerably improved after the intervention. The Number Chain Game significantly enhanced the students' comprehension of geometric concepts, as demonstrated by the massive t-value and incredibly low p-value ($p < .001$). It could be because of the game's dynamic and captivating nature, which enhanced students' motivation, concentration, and conceptual grasp of geometry concepts. No insignificant findings were discovered because every p-value in Table 3 was below the 0.05 level. It suggests that the intervention had a significant effect on the variable being measured.

Research has established that game-based approaches increase students' cognitive activity, critical thinking, and problem-solving in mathematics (Karakoç et al., 2022). The interactive and collaborative learning approach of the Number Chain Game mirrors the values of inquiry-based and experiential learning, which are efficient in cultivating analytical reasoning (Pan & Ke, 2023). The capability of non-computer games to enhance analytical abilities in geometry, where the study pointed to contextual learning and collaborative interaction in enhancing mathematical reasoning (Maryana et al., 2024). Such studies validate that the Number Chain Game is a helpful approach in greatly enhancing students' analytical minds in geometry.

The results suggest that integrating game-based learning techniques, like the Number Chain Game, into geometry education can have a profound effect on students' analytical capabilities. It encourages teachers to transition from conventional, lecturing pedagogies to more dynamic, student-oriented methodologies that facilitate critical thinking, teamwork, and more solid conceptual comprehension. It also makes a case for the promise of non-digital games as effective and affordable pedagogical resources to facilitate higher-order thinking within mathematics classrooms and challenges curriculum writers and school leaders to include these strategies in their teaching of geometry and other areas of mathematics.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

Table 3. Significant difference in students' analytical thinking in geometry before and after the implementation of the Number Chain Game

Variables	M	SD	T value	P value
Analytical thinking in geometry before the implementation of the Number Chain Game	13.11	3.94	27.80***	0.000
Analytical thinking in geometry after the implementation of the Number Chain Game	34.89	3.14		

Note: *** $p < .001$ (Highly Significant) **$p \leq 0.01$ (Highly Significant); *$p < 0.05$ (Significant); $p > 0.05$ (Not significant)

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A study was conducted at a particular secondary public school in Ozamiz City during the academic year 2024–2025 to use the Number Chain Game to enhance the analytical thinking of grade 8 geometry students. The study employed a classroom-based action research methodology, and 27 students were selected using purposive sampling. Data was collected via a test created by the researcher, and analysis involved paired t-tests, mean and standard deviation calculations, and more. The study's specific objectives were to:

(1) determine the students' analytical thinking in geometry before the implementation of the Number Chain Game; (2) determine the students' analytical thinking in geometry after the implementation of the Number Chain Game; and (3) identify a significant difference in students' analytical thinking in geometry before and after the implementation of the Number Chain Game.

Findings

Among the primary findings of the study were the following:

1. Prior to the introduction of the Number Chain Game, some students' analytical thinking skills fell short of expectations, and they performed poorly in geometry.

2. The introduction of the Number Chain Game significantly enhanced the students' analytical thinking; most of them achieved exceptionally high scores, and the class as a whole was rated as exceptional.

3. Students' analytical thinking before and after the Number Chain Game was introduced differed in a highly significant way, according to the study.

Conclusions

The data lead to the following conclusions:

1. Geometry continues to be a complex topic among students, especially in developing their analytical thinking skills that impact the ability to reason and solve problems efficiently. These skills must be developed using interactive and student-centered methods of teaching.

2. The Number Chain Game is used to improve students' analytical thinking and comprehension of geometric topics. It also enhances valuable skills such as critical thinking, problem-solving, and active engagement in the learning process.

3. The Number Chain Game is an effective teaching strategy in mathematics education, especially in geometry. Stronger conceptual understanding and a more engaging and rewarding educational experience are two advantages for students.

Recommendations

Given the outcomes and conclusions, it is suggested that:

1. Teachers may incorporate game-based approaches such as the Number Chain Game in the teaching of geometry to enhance analytical thinking among students and enhance interest in mathematical problem-solving.

2. Administrators in schools may facilitate training and workshops on interactive and student-centered teaching techniques to enable educators to shift away from conventional, lecture-based pedagogy.

3. Mathematics teachers may continually seek innovative approaches to instruction that encourage higher-order thinking, teamwork, and active learning to enhance students' performance in geometry and mathematics as a whole.

4. Future research should include a control or comparison group to strengthen causal inferences. Expanding the sample size across multiple schools or grade levels would improve external validity. Incorporating longitudinal tracking would help measure the sustainability of improved analytical skills over time. The paper could be streamlined by reducing repetitive literature and presenting findings in more concise visual forms (e.g., charts or infographics). Exploring teacher training, scalability, and integration with digital tools could enhance its practical applicability and influence curriculum development in mathematics education.

REFERENCES

1. Abdurashidova, M., Balbaa, M. E., Nematov, S., Mukhiddinov, Z., & Nasriddinov, I. (2023). The impact of innovation and digitalization on the quality of higher education: A study of selected universities in Uzbekistan. Journal of Intelligent Systems, 32(1), 20230070.
2. Balbaa, M. E., & Abdurashidova, M. (2023). Enhancing Student Engagement and Learning Outcomes Through Gamification in Education. Technology and Education, 13.
3. Dai, C. P., Ke, F., & Pan, Y. (2022). Narrative-supported math problem solving in digital game-based learning. Educational technology research and development, 70(4), 1261-1281.
4. Karakoç, B., Eryılmaz, K., Turan Özpolat, E., & Yıldırım, İ. (2022). The effect of game-based learning on student achievement: A meta-analysis study. Technology, Knowledge and Learning, 27(1), 207-222.
5. Moon, J., & Ke, F. (2020). In-game actions to promote game-based math learning engagement. Journal of Educational Computing Research, 58(4), 863-885.
6. Pan, Y., & Ke, F. (2023). Effects of game-based learning supports on students’ math performance and perceived game flow. Educational technology research and development, 71(2), 459-479.
7. Letsa-Agbozo, J. K., Susuoroka, G., & Donnoe, M. A. (2023). THE EFFECTS OF GAME-BASED MATHEMATICS LEARNING ON PUPILS ' ACADEMIC PERFORMANCE IN JUNIOR HIGH SCHOOL.
8. Yusof, N. A. M., & Shahrill, M. (2021). The effects of non-digital game-based learning on Brunei Darussalam students’ mathematical perspectives and achievements. Southeast Asian Mathematics Education Journal, 11(1), 25-40.
9. Tangkui, R., & Keong, T. C. (2020). Enhancing pupils' higher-order thinking skills through the lens of activity theory: Is digital game-based learning effective?. International Journal of Advanced Research in Education and Society, 2(4), 1-20.
10. Ramli, I. S. M., Maat, S. M., & Khalid, F. (2022). Sustainable Mathematics Learning Using Digital Game-Based Learning: The impact on students' self-efficacy and mathematics achievement. International Journal of Academic Research in Progressive Education and Development, 11(2).
11. Tapia-Nunez, S. (2021). The Effect of Problem-Based Learning and Game-Based Learning on Student Achievement and Student Engagement (Master's thesis, The William Paterson University of New Jersey).

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VIII August 2025

12. Kartika, D. L. (2023). Application of the Kahoot game-based problem-based learning model to increase motivation and learning achievement in calculus. Union: Jurnal Ilmiah Pendidikan Matematika, 11(3), 507-516.
13. Purnani, I., Negara, H. R. P., Kurniawati, K. R. A., Negara, H. R. P., & Sucipto, L. (2024, April). Implementation of Gamification Techniques in Mathematics Education: A Study on Student Engagement and Learning Outcomes. In Proceedings of International Seminar on Student Research in Education, Science, and Technology (Vol. 1, pp. 110-122).
14. Maryana, M., Halim, C., & Rahmi, H. (2024). The Impact of Gamification on Student Engagement and Learning Outcomes in Mathematics Education. International Journal of Business, Law, and Education, 5(2), 1697-1608.
15. Montenegro-Rueda, M., Fernández-Cerero, J., Mena-Guacas, A. F., & Reyes-Rebollo, M. M. (2023). Impact of gamified teaching on university student learning. Education Sciences, 13(5), 470.
16. Gómez Niño, J. R., Árias Delgado, L. P., Chiappe, A., & Ortega González, E. (2024). Gamifying Learning with AI: A Pathway to 21st-Century Skills. Journal of Research in Childhood Education, 1-16.
17. Navarro-Espinosa, J. A., Vaquero-Abellán, M., Perea-Moreno, A. J., Pedrós-Pérez, G., Martínez-Jiménez, M. D. P., & Aparicio-Martínez, P. (2022). Gamification as a motivational tool for creating sustainable higher education institutions. International Journal of Environmental Research and Public Health, 19(5), 2599.
18. Bueno, J. S., Pérez-Villarejo, L., Eliche-Quesada, D., La Rubia, M. D., Romero-García, J. M., Romero-Pulido, I., ... & Galán-Martín, A. (2024). LEARNING IMPROVEMENT THROUGH GAMIFICATION IN ENGINEERING COURSES. In EDULEARN24 Proceedings (pp. 6226-6230). IATED.
19. Jato-Espino, D., Vila-Cortavitarte, M., Rodriguez-Hernandez, J., & Castro-Fresno, D. (2024). Gamification as a Tool to Improve Educational and Training Outcomes in Civil Engineering. Journal of Civil Engineering Education, 150(4), 03124001.
20. Saldivar, J. M. N. (2024). Embarking on a Gamified Journey in Higher Education: A Meta-synthesis. European Online Journal of Natural and Social Sciences, 13(3), pp. 259.
21. Rincon-Flores, E. G., Santos-Guevara, B. N., Martinez-Cardiel, L., Rodriguez-Rodriguez, N. K., Quintana-Cruz, H. A., & Matsuura-Sonoda, A. (2023). Gamit! Icing on the Cake for Mathematics Gamification. Sustainability, 15(3), 2334.
22. Lo, C. K., & Hew, K. F. (2021). Student engagement in mathematics flipped classrooms: Implications of journal publications from 2011 to 2020—Frontiers in Psychology, 12, 672610.
23. Statology. (2020). Pretest-Posttest Design: Definition & Examples. Retrieved from [Statology](https://www.statology.org/pretest-posttest-design/)
24. Fiveable. (n.d.). Convergent Design - Communication Research Methods. Retrieved from [Fiveable](https://library.fiveable.me/key-terms/communication-research-methods/convergent-design).