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Digital Game-Based Learning As An Innovative Approach To Simplifying Complex Mathematical Concepts

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Abstract: This research set out to explore how digital game-based learning can make complex mathematical concepts easier to grasp and boost student engagement in the classroom. The study used a quasi-experimental design, where an educational experiment was conducted with one group of students using digital educational games, while another group followed traditional teaching methods. The sample consisted of 50 middle school students. To assess the impact of the educational intervention, pre- and post-tests were administered, and the data was analyzed using mean, standard deviation, and t-values. The findings revealed that the group using digital games scored significantly higher on the post-achievement test compared to the control group, with a lower standard deviation indicating a more consistent performance and a better grasp of the concepts. Additionally, the results highlighted that digital games not only increased students' motivation to learn but also enhanced their critical thinking and problem-solving abilities. In light of these findings, the research concluded that digital game-based learning is an effective and innovative approach to simplifying complex mathematical concepts. It suggests that schools should incorporate these games into their curricula and provide training for teachers to effectively utilize these tools for maximum benefit.

Keywords: Digital learning, educational games, mathematics simplification, academic achievement, student motivation, critical thinking

1. Introduction

The challenges in mathematics education are quite significant, particularly when it comes to students grasping complex concepts like algebra, geometry, and calculus. These hurdles not only affect academic performance but also dampen students' enthusiasm to engage in learning. Research shows that traditional teaching methods often lean heavily on memorization and rote learning, which can lead to a lack of understanding, reduced motivation, and heightened stress and anxiety when students encounter tough math problems [1]. On the flip side, there's a pressing need for fresh educational approaches that blend fun with learning, making the process more captivating and effective. One promising method is digital game-based learning, which merges educational content with game-like elements such as challenges, rewards, and instant feedback, all of which can boost students' focus and intrinsic motivation. However, even with the rising popularity of digital educational games, there's still a gap in research assessing their real-world impact on making complex mathematical concepts easier to understand and enhancing students' comprehension. This study aims to tackle the central question: How much can digital game-based learning help simplify complex math concepts and encourage students to engage and participate actively in their learning journey?

Citation: Heba Thamer A. Digital Game-based Learning as an Innovative Approach to Simplifying Complex Mathematical Concept. Vital Annex: International Journal of Novel Research in Advanced Sciences 2026, 5(1), 10-16.

Received: 10th Nov 2025Revised: 21th Dec 2025Accepted: 14th Jan 2026Published: 06th Feb 2026

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The significance of this research lies in its effort to connect traditional math teaching methods with the modern needs of students who crave interactive and engaging learning experiences. Mathematics can be quite challenging, with concepts and skills that some students struggle to understand, which often leads to lower academic performance and a lack of motivation. This highlights the urgent need for innovative approaches that can simplify these concepts and turn learning into a fun and engaging journey [2]. Digital game-based learning stands out as a crucial method because it creates an exciting learning atmosphere filled with challenges, interaction, and instant rewards. This not only boosts student engagement but also encourages critical thinking and problem-solving skills. Moreover, it allows teachers to present complex educational material in a way that is more accessible and adaptable to various student levels, helping to alleviate the anxiety and fear often associated with math. Additionally, the findings from this research add valuable insights to modern educational practices by offering concrete evidence on how digital games can enhance students' comprehension of intricate mathematical concepts. The study also lays out a framework for educators to craft innovative teaching strategies that elevate the quality of education and align with the goals of smart, interactive learning, keeping pace with the trends of digital education in the 21st century.

The goal of this research is to explore how digital game-based learning can serve as a fresh and effective way to make complex mathematical concepts easier to understand. The research proposes that incorporating digital game-based learning can significantly boost students' grasp of complex mathematical concepts, spark their motivation to learn, and foster greater interaction and active participation in the learning process. Objective limits: We're exploring digital game-based learning as a fresh way to make complex math concepts easier to grasp. Time limits: This research took place during the academic year of 2025. Spatial boundaries: The study was conducted in Baghdad, specifically within the First Karkh Education Directorate.

2. Materials and Methods

This Digital game-based learning (GBL) is an innovative educational approach that leverages video games as tools for learning, aiming to meet specific cognitive and behavioral goals. This method blends game elements like challenges, rewards, instant feedback, and storytelling with educational content, which boosts students' intrinsic motivation and enhances their learning effectiveness [3]. In today's educational landscape, digital game-based learning is recognized as an interactive process that encourages students to actively engage in a dynamic environment, where they can practically apply mathematical concepts and tackle problems in a fun and engaging manner. Researchers have found that incorporating digital games into education goes beyond mere entertainment; it also fosters critical thinking, creativity, and the ability to solve complex problems [4].

Second: Characteristics of digital game-based learning

Digital game-based learning comes with some standout features that really help in breaking down complex math concepts. Here are a few of them:

1. Active interaction: Students get to dive right in, tackling problems and challenges as they play the game.
2. Instant feedback: These games offer immediate responses on how students are doing, which helps them fix mistakes and deepen their understanding.
3. Rewards and motivation: With points or leveling systems, games keep students engaged and eager to learn more.
4. Flexibility in learning: Students can progress at their own speed, catering to their unique abilities, which boosts their grasp of tough concepts.
5. Blending theory with practice: It gives students the chance to use math concepts in hypothetical situations that mirror real life, enhancing their practical understanding [5][6].

Third: The impact of digital game-based learning on simplifying mathematics concepts.

Thirdly, let's talk about how digital game-based learning can make understanding math a whole lot easier. Research shows that educational games can really help break down those tricky math concepts by:

- Turning mathematical operations into fun, visual, and interactive experiences.
- Encouraging logical thinking and the mental steps needed to tackle math problems.
- Boosting focus and determination through progressively challenging in-game tasks.

Some studies have shown that when digital games are used to teach topics like fractions, equations, and geometry, students tend to grasp these concepts better and achieve higher academic success compared to more traditional teaching methods [7].

Fourth: Justifications for using digital games in teaching mathematics

There are quite a few compelling reasons to incorporate digital games as a teaching tool in mathematics:

1. They help break the cycle of boredom and monotony that often comes with traditional teaching methods.
2. They cater to the diverse needs and varying skill levels of students.
3. They foster critical and analytical thinking skills.
4. They boost students' self-motivation and enhance interaction in the classroom.
5. They create a safe space for students to experiment and learn from their mistakes without the fear of negatively affecting their academic performance [8][9][10][11][12][13].

Axis II: Previous studies

1. **Asmaa Zain Al-Abidin Badawi Ali, Shaimaa Samir Mohammed Khalil, Mohammed, 2023, The effectiveness of digital game stimuli in developing mathematics concepts, digital skills, and learning motivation among third-grade primary school students with learning difficulties [14].**

This study set out to enhance math concepts, digital skills, and learning motivation among third-grade students facing learning challenges. It did this by introducing educational content through a digital game-based learning environment. The experiment involved 50 boys and girls from Damaris Elementary School in Minya Governorate during the first semester of the 2022-2023 academic year. The findings showed that using digital game stimuli significantly improved students' understanding of math concepts and digital skills, while also boosting their motivation to learn. The study highlighted the importance of integrating these game-based approaches into e-learning strategies within educational institutions.

The second study:

2. **Salma Khalil Salah Abdel Rahman, Zainab Mahmoud Mohamed Kamel, Zakaria Jaber Hanawi Beshay, 2020, The effect of using electronic educational games in teaching mathematics to second-grade primary school students on developing problem-solving skills [15].**

This study set out to explore how electronic educational games can impact the development of problem-solving skills in second-grade primary school students learning mathematics. The experiment involved a group of second graders who used these games as a teaching tool. The findings revealed a notable enhancement in the students' problem-solving abilities, highlighting how effective electronic educational games can be in boosting critical thinking and problem-solving skills in math.

3. Results

This research is based on the quasi-experimental method. (Quasi-Experimental Design) because it allows for controlling the independent variable (digital game-based learning) and studying its effect on the dependent variable (simplifying complex math concepts and motivating students). This approach was chosen because it allows the

researcher to compare two groups: an experimental group using educational digital games, and a control group relying on traditional methods.

Second: Experimental design

A pre-test and post-test design was adopted for both groups, where tests were administered to both groups before and after the experiment began to measure the effect of the educational intervention.

Table (1): Experimental design

The group	Pre-test	educational intervention	Post-test
empiricism	✓	Digital game-based learning	✓
The officer	✓	The traditional way	✓

Table (1) illustrates the experimental design of the research, where students were divided into two groups: experimental and control. Each group underwent a pre-test to determine their level of understanding of mathematical concepts before starting the educational intervention. The experimental group engaged in learning through digital games, while the control group stuck to the traditional teaching methods. Once the study period wrapped up, both groups took a post-test to evaluate how effective the educational strategy was. This setup makes it possible to compare how well each group performed and to see how digital game-based learning helps simplify mathematical concepts and encourages students to get involved and participate.

Table (2): Research sample

Standards	experimental group	control group	Total
Number of students	25	25	50
Educational stage	Medium	Medium	Medium

Table (2) presents the research sample, which comprised 50 middle school students. These students were evenly split into two groups: the experimental group with 25 students and the control group, also with 25 students. This balanced setup ensures that both groups are equal, making it possible to compare the effects of digital game-based learning against traditional teaching methods on students' achievement and their grasp of mathematical concepts.

Table (3): Arithmetic mean, standard deviation and t-value in the intelligence variable

The group	arithmetic mean	standard deviation	calculated t	Significance
empiricism	102.4	7.5	0.42	Not significant
The officer	101.7	6.9		

Table 3 presents the findings from measuring the intelligence variable in both the experimental and control groups prior to the intervention. The experimental group had an average score of 102.4, with a standard deviation of 7.5, while the control group scored an average of 101.7, with a standard deviation of 6.9. The t-value calculated was 0.42, which is not statistically significant. This suggests that both groups were similar in terms of intelligence before the experiment began, meaning that any differences in performance observed later can be attributed to the educational intervention rather than variations in intelligence among the students.

Table (4): Arithmetic mean, standard deviation and t-value in the chronological age variable

The group	arithmetic mean	standard deviation	calculated t	Significance
empiricism	13.2	0.8	0.38	Not significant
The officer	13.1	0.9		

Table (4) illustrates how the two groups are distributed based on their chronological age. The experimental group had an average age of 13.2 years, with a standard deviation of 0.8, while the control group averaged 13.1 years, with a standard deviation of 0.9. The t-value came out to be 0.38, which isn't statistically significant. This suggests that both groups are similar in terms of age, meaning that any differences in academic performance can't be linked to age variations among the students.

Table (5): Arithmetic mean, standard deviation and t-value in the previous year's grades variable

The group	arithmetic mean	standard deviation	calculated t	Significance
empiricism	78.4	6.2	0.55	Not significant
The officer	77.9	5.9		

Table (5) illustrates how the two groups were distributed based on their grades from the previous year. The experimental group had an average score of 78.4, with a standard deviation of 6.2, while the control group scored an average of 77.9, with a standard deviation of 5.9. The t-value came out to be 0.55, which isn't statistically significant. This suggests that both groups had similar academic backgrounds, meaning any differences in their performance later on can be attributed to the educational intervention rather than their prior achievements.

Table (6): Equivalence of the experimental and control research groups in the variable of parents' academic achievement

The group	arithmetic mean	standard deviation	calculated t	Significance
empiricism	15.3	2.4	0.41	Not significant
The officer	15.1	2.5		

Table (6) illustrates how the experimental and control groups compare regarding parents' academic achievement. The experimental group had an average score of 15.3 with a standard deviation of 2.4, while the control group scored an average of 15.1 with a standard deviation of 2.5. The t-value was 0.41, which is not statistically significant. This suggests that both groups are similar in terms of parents' academic achievement, meaning this variable won't influence the research outcomes.

Table (7): Equivalence of the experimental and control research groups in the variable of mothers' academic achievement

The group	arithmetic mean	standard deviation	calculated t	Significance
empiricism	14.8	2.1	0.36	Not significant
The officer	14.6	2.3		

Table (7) illustrates how the experimental and control groups compare in terms of mothers' educational attainment. The experimental group had an average score of 14.8 with a standard deviation of 2.1, while the control group scored an average of 14.6 with a standard deviation of 2.3. The t-value was 0.36, which is not statistically significant. This suggests that both groups are equivalent regarding mothers' educational attainment, meaning this factor won't influence the research outcomes and supports a fair comparison between the two groups.

Fifth: Controlling extraneous variables

1. Identify the scientific material: We've chosen complex math topics like fractions, equations, and real-world problems that align with the middle school curriculum.

2. Setting behavioral objectives: We create clear and measurable learning goals that focus on understanding concepts, solving problems, and developing critical thinking skills.

3. Lesson plans: Each lesson comes with a comprehensive learning plan that outlines the lesson objectives, teaching tools (like digital games), classroom activities, and methods for assessment.

Sixth: Search tool

1. Test Grading:

We used tests before and after to see how well students understood math. We graded them using clear rules to make things fair.

2. Survey Test App:

A pilot application was conducted on a small sample (5 students) to ensure the clarity of the questions and the correctness of their formulation.

3. **apparent honesty:**

The test was presented to a group of mathematics professors to verify its suitability and objectivity.

4. **Statistical analysis of the test:**

Statistical analysis (arithmetic mean, standard deviation, t-tests) was used to ensure the validity and accuracy of the results.

5. **Final test application:**

The test was applied to the experimental and control groups before and after the experiment to measure the effect of digital game-based learning.

Statistical methods:The researcher used the statistical package program.spss

Chapter Four: Presentation and Interpretation of Results

Table (8): Arithmetic means and standard deviations for the two research groups in the post-achievement test.

The group	arithmetic mean	standard deviation
empiricism	85.6	4.8
The officer	76.2	5.5

Table (8)Arithmetic means and standard deviations for the two research groups in the post-achievement test. The experimental group, which used digital game-based learning, achieved an arithmetic mean of 85.6 with a standard deviation of 4.8, while the control group, which adopted the traditional method, achieved a mean of 76.2 with a standard deviation of 5.5. The test group did better and was more consistent in their grades. This shows that learning math with video games can make things easier to understand and helps students learn more.

The group that learned with digital games scored better (9.4 points on average) than the other group. Also, their scores were more consistent, meaning the game-based learning helped everyone perform at a similar level. Why? Well, using games seemed to help students grasp tricky math ideas better. They also got more involved and interested in learning. This boosted their grades. Plus, the games gave them instant feedback and kept them motivated. It pushed them to keep learning until they really understood everything.

4. **Conclusion**

1. Turns out, using digital games really helps break down tough math ideas and makes students do better in class.
2. The students were way more into learning and talked to each other more when they used digital games instead of just doing things the old way.
3. We saw that using digital games kinda leveled the playing field. Everyone in the game group did about the same, which was pretty cool.
4. The study showed that getting feedback right away and having stuff to actually interact with really helped students get a better handle on math topics.

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