DESIGNING AND USING LEARNING GAMES FOR THIRD GRADERS TO ENHANCE MATHEMATICS PERFORMANCE AND MOTIVATION

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Abstract

Within the dynamic realm of competency-based education, the establishment of meaningful and engaging learning environments is crucial. Consequently, there has been an increasing scholarly interest in exploring the utilization of games in teaching and learning. However, most games in recent research aim to engage students in practice-and-drill activities. Our research focuses on the application of manually designed learning games, based on the Experiential Learning Theory, within a primary school in Ho Chi Minh City, involving 208 third-grade students. Using a quasi-experimental design with a pre-post intervention evaluation, the study aims to assess the impact of these games on students' academic performance in mathematics and their motivation towards the subject. The findings, derived from quantitative data analysis, reveal significant improvements in both academic performance and motivation post-intervention. This research contributes to the growing body of knowledge on gamified learning and offers practical methods to integrate student engagement. It underscores the value of well-structured, theoretically grounded learning games as an effective tool in modern educational practices, especially for complex subjects like mathematics at the elementary level.

Keywords: *Competency-based education, experiential learning, learning games, mathematics, primary education.*

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THIẾT KẾ VÀ SỬ DỤNG TRÒ CHƠI HỌC TẬP NHẰM NÂNG CAO HIỆU QUẢ VÀ ĐỘNG LỰC HỌC TẬP HỌC TOÁN CHO HỌC SINH LỚP 3

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Tóm tắt

Trong bối cảnh giáo dục phát triển năng lực hiện nay, việc xây dựng môi trường học tập có ý nghĩa và tích cực là rất quan trọng. Do đó, trong những năm gần đây, trò chơi học tập là một trong những chủ đề nghiên cứu thu hút nhiều sự quan tâm. Tuy nhiên, hầu hết nghiên cứu về trò chơi gần đây đều có mục tiêu thúc đẩy học sinh trong hoạt động luyện tập, ôn lại kiến thức đã học. Nghiên cứu này tập trung vào việc thiết kế và sử dụng trò chơi học tập, dựa trên lý thuyết học tập trải nghiệm, với sự tham gia của 208 học sinh lớp ba tại Thành phố Hồ Chí Minh. Với thiết kế bán thực nghiệm theo cách tiếp cận đánh giá trước và sau can thiệp, nghiên cứu đánh giá tác động của các trò chơi này đối với kết quả học tập và động lực học của học sinh trong môn Toán. Kết quả phân tích định lượng cho thấy có sự cải thiện đáng kể cả về kết quả học tập và động lực học sau can thiệp. Nghiên cứu cung cấp thêm bằng chứng thực nghiệm về sử dụng trò chơi trải nghiệm để hình thành kiến thức toán cho học sinh tiểu học, đồng thời cung cấp thêm ý tưởng dạy học cho các giáo viên đang tìm cách tích hợp các phương pháp giảng dạy hấp dẫn vào lớp học. Bài viết nhấn mạnh giá trị của các trò chơi học tập được thiết kế với cấu trúc tốt và sử dụng dựa trên lý thuyết học tập hiện đại.

Từ khóa: *Giáo dục tiểu học, học tập trải nghiệm, phát triển năng lực, Toán học, trò chơi học tập.*

1. Introduction

Over the past 30 years, the use of learning games has garnered significant attention across various dimensions, particularly in the field of education (Chen et al., 2022). Empirical studies from many parts of the world (Bartfay & Bartfay, 1994; Karbownik et al., 2016; Lin & Cheng, 2022; Martins et al., 2018; Zeedyk et al., 2001; Viggiano et al., 2015) and in Vietnam (Ho et al., 2017; Nguyen & Hua, 2022) have contributed to substantiating that learning games enhance academic achievement and knowledge development. Beyond its effectiveness in knowledge enhancement, several studies have also indicated that games provide opportunities for students to develop cognitive (Iizuka et al., 2018; Panphunpho et al., 2013; Park & Lee, 2017; Sala et al., 2015), including studies in Vietnam & Hua, 2022; Pham, 2018). In addition, some studies (Blasco-Fontecilla et al., 2016; Kim et al., 2014; Lin et al., 2015) have emphasized that learning games play a significant role in aiding children with symptoms of inattention, enhancing concentration, and memory skills. Furthermore, some international studies have demonstrated that engaging in games contributes to the enhancement of social skills (Fang et al., 2022). Importantly, learning games have been proven to develop motivation, increase enthusiasm, create a joyful and happy mindset, and foster a love for learning, as evidenced by international (Bartfay & Bartfay, 1994; Laurens et al., 2018) and in Vietnam (Ho et al., 2017; Pham & Ngo, 2015).

Regarding the use of learning games in elementary mathematics education, empirical studies have also revealed a variety of benefits. Games specifically have been shown to increase enjoyment and happiness in learning mathematics (Lin & Cheng, 2022; Lin & Wang, 2022; Nguyen et al., 2022; Nguyen & Hua, 2022; Pham & Ngo, 2015). In addition, using games has been suggested as an effective way to reinforce and review knowledge, thus improving academic achievement (Ho et al., 2017; Lin & Cheng, 2022; Nguyen & Hua, 2022). Moreover, skillfully crafted games can provide students with chances to apply their knowledge, leading to a profound understanding of mathematical concepts, a challenge not easily overcome through traditional exercises (Lin & Cheng, 2022; Nguyen et al., 2022; Tran, 2021). It can be stated that, given the abstract nature of mathematical concepts, there is a need to develop gaming environments to create a positive, motivational learning atmosphere, simultaneously helping students grasp the essence of mathematical principles.

With those mentioned benefits, using learning games has recently become a research topic of growing interest in Vietnam. However, as shown in Table 1, the majority of recent studies at the primary education level mainly used games to practice and review knowledge, which was also mentioned by previous studies (Nguyen et al., 2022; Tran, 1999). There is a lack of studies that use games to construct new knowledge. Besides, most games in those studies have yet to be theoretically specified, highlighting the need for research on the use of classroom learning games under specific learning theory models.

Table 1. Overview of the current usage and theoretical frameworks of learning games

Author	Year	Class & Subject	Game Genre	Usage
Hoang Ngoc Anh et al.	2013	Elementary Mathematics	Online game	Review, Practice
Pham Hai Le and Ngo Thi Thanh Phuong	2015	Mathematics 3	Use Dominoes, dice, card sets, and wooden sticks	Review, Practice
Vu Hoang Son	2017	History 4	Multiple choice, crossword puzzle, matching, lottery	Warm-up; Exploration & Review, Practice
Pham Thi Tham	2018	Vietnamese 1	Multiple choice, short answer, filling in and arranging words, connect the dots.	Warm-up; Review, Practice
Tran Thi Tu	2019	Physical Education 2	Physical games	Review, Practice

Author	Year	Class & Subject	Game Genre	Usage
Nguyen Quang Hung and Hua My Linh	2022	Mathematics 3 & 4	Multiple choice, fill in the blanks, and digital games on Kahoot!	Review, Practice
Nguyen Minh Giang et al.	2022	Mathematics 1	Board games, physical games	Warm-up; Exploration & Review, Practice
Nguyen Ngoc Qui	2023	Preschool and elementary ages	Physical games, folk games	Review, Practice
Le Thi Thanh Tam	2023	Mathematics 4	Pass objects and answer questions, build flat puzzles, observe and find	Exploration & Review, Practice
Doan Thi Van et al.	2023	Experiential activities 2	Bingo games (Choose the correct answer)	Warm-up; Review, Practice

To fill the two identified gaps in the existing literature, this study was conducted with the aim of proposing ideas for the design and use of learning games that help students construct new mathematics concepts. We aim to evaluate changes in students' mathematics learning outcomes and learning motivation. Specifically, the research will address the following two questions:

1) Regarding students' learning achievement, is there a significant difference between students learning with games and those learning through conventional teaching methods?

2) Regarding students' Mathematics motivation, is there a significant difference between students learning with learning games and those learning through conventional teaching methods?

2. Theoretical background

2.1. Learning games

The gaming landscape has captivated widespread attention and embraces a multitude of perspectives, leading to ongoing debates about the very definition of a "game", Juul (2005) characterize games as "voluntary activities with rules, producing specific outcomes (winning or losing) or providing measurable feedback (points), facilitating reliable comparisons of player performance" (Juul, 2005; Klopfer et al., 2009). In line with this, Juul (2005) notes that diverse outcomes are linked to different values, requiring players to strive for optimal results. In terms of decisions, Meier (2020), a renowned figure in game design, emphasizes that a game unfolds through a sequence of captivating decisions, whereas, Burgun (2013), in his work Game Design Theory, offers a more constrained definition of a game: "a system of rules in which agents compete by making ambiguous, endogenously meaningful decisions" (Burgun, 2013; Meier, 2020). Regarding the pleasure aspect, Schell (2008), in "The Art of Game Design" defines a game as a problem-solving activity approached with a playful attitude, aligning with perspective of Suits and Hurka (1978). Schell (2008) as well as Suits and Hurka (1978) highlight the player's playful mindset as crucial in crafting a game. Despite varying definitions, researchers generally concur that the structure of a game typically involves rules, goals, feedback, interaction, and outcomes.

In the context of this study, a "learning game" is understood as a system of fixed gaming rules whereby participants achieve gaming objectives concurrently with learning goals. In this framework, players not only experience a lively and enjoyable environment but also encounter educational elements. These factors contribute to a positive learning experience, fostering curiosity and enthusiasm from the players. This can enhance learning performance and make the learning process more engaging.

In terms of characteristics of learning games, Tran (1999) identifies four, namely: (1) Having clearly defined rules, often devised by teachers for educational purposes; (2) Having a strict structure, consisting of elements such as the play task (cognitive task), gameplay actions, and game rules; (3) The name of it typically reflect the game's content and stimulate children's interest in the game; (4) Always yielding specific outcomes. This study will employ these four characteristics to design learning games, as outlined in the subsequent section.

The concept and characteristics of learning games have been outlined above, however, it is necessary to raise the question of how to effectively use them to facilitate the exploration of new mathematical knowledge. To address this, it is imperative to examine this approach through the lens of a grounded learning theory, such as Constructivism, Cognitivism, and Behaviorism. Many researchers consider learning games as “a form of experience”, where the goals of playing and learning are blended (Hussein et al., 2022; Powers & Moore, 2021) Besides, some research suggested that using games in instructional activities should include gameplay stage and games debriefing stage (Villa III et al., 2023), which means students start with playing games, then thinking, and communicating to generalize gameplay and build new knowledge. Considering those two points of view, this research adopts David Kolb's experiential learning theory as a guiding framework for integrating learning games into mathematics instruction.

2.2. Experiential Learning Theory

According to Kolb (1984), learning is a dynamic process that occurs through direct engagement with experiences, and it emphasizes the importance of reflection and active experimentation in the learning process. Kolb's significant contribution to the field of education is the development of a model of the experiential learning cycle, comprising four stages: (1) Concrete Experience; (2) Reflective Observation; (3) Abstract Conceptualisation; (4) Active Experimentation. If a game is considered an “experience”, it can be effectively incorporated into this theory to enhance the learning process.

In the concrete experience stage, students have immersed themselves in the game, actively participating and experiencing the gameplay. After the game session, students move to the reflective observation stage, in which they facilitate a reflective discussion or debriefing. They are also encouraged to share their observations and experiences during the game. Teachers can ask open-ended questions to stimulate reflection, like “What did you notice during the game?”, or “What strategies did you use, and why?”.

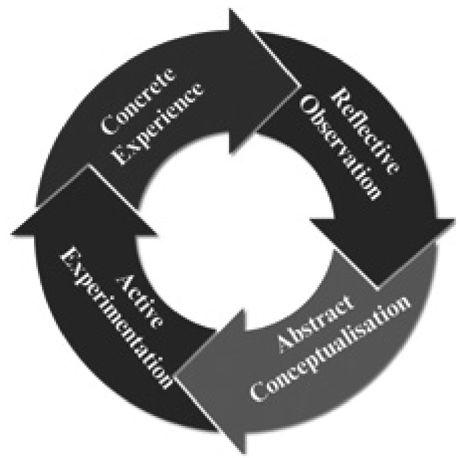

Figure 1. David Kolb’s Model of Experiential Learning

The next step is the transition to the abstract conceptualization phase by connecting the game experiences to broader concepts, theories, or learning objectives. Students are encouraged to extract general principles, lessons, or takeaways from the game. Discuss how the game relates to real-life situations or challenges. Finally, in the active experimentation stage, teachers provide opportunities for students to apply what they have learned from the game in practical scenarios or activities. This four-stage strategy can be implemented in the form of lesson plan in Appendix 3 of Official Dispatch 2345 (Ministry of Education and Training, 2021) as shown in Table 2 below.

Table 2. The integration of 4 steps between Official Dispatch 2345’s activities and steps in the Experiential Learning Theory

Stage	Lesson (Official Dispatch 2345)	Lesson’s structure (Experiential learning game)
1	Warm-up	Engaging in gaming experience
2	Exploration	Reflecting and abstracting conceptualization: analyzing gaming experience (rules, gameplay process, strategies) then generalizing and summarizing new knowledge or skills
3	Practicing	Practicing
4	Application	Active Experimentation: new gameplay at advanced levels

3. Designing learning games

Based on the theoretical background above and the educational game's structure proposed in the study by Denham et al. (2016), we present the four games used in the intervention in Table 3 below.

Table 3. Description of games

Structure		Multiplying a Number by a Number		Reducing a Number by a Number	
Name of game		Game 1.1: Magical tape	Game 1.2: Hunter	Game 2.1: Arrange evenly	Game 2.2: Who's lucky?
Goal	**Learning**	Get familiar with the folding action of “increase a number by some times”	Review “multiply”, distinguishing with addition	Get familiar with the folding action of “reducing a number by some times”	Review four calculations
	Playing	To be the 1st person to reach the finish line	To be the 1st group collect the most gifts	To be the 1st person to divide paper quickly	To be the 1st group collect the most gifts
Challenge	Select and move chess pieces when drawing command cards by folding/ additional steps	Calculate and choose the right gift	Divide so that the two strips of paper are equal	Calculate and choose the right gift	
Core Mechanics	Students draw command cards determining their moves (e.g., fold card (as multiplying) or step up card (adding)	Starting with 10 points, multiplying or adding based on drawn cards, and choose gifts	Dividing large paper into small strips, first visualizing by hand (Round 1) and then using only vision (Round 2)	Groups start with 10 points, calculate based on cards (4 calculations), and choose gifts	
Material	A_3 paper, chess pieces, command cards	Command cards	A_3 paper	Command cards	

Those games have been designed to support the learning of basic arithmetic operations through practical activities. In Game 1.1, students are required to perform the action of folding paper based on the number determined by drawing a command card. It should be noted that in Vietnamese, the act “folding/gấp” can help students understand that specific mathematical word related to multiplication. Game 1.2 has a similar design of an advanced level, promoting the application of knowledge through drawing cards to increase points and exchange for prizes, with the cards containing only addition and multiplication operations. Games 2.1 and 2.2 are similar, emphasizing the ability to reduce a certain number through activities such as evenly distributing paper strips and drawing cards to exchange for prizes, incorporating all four basic arithmetic operations. This helps students actively apply their knowledge and distinguish between addition-multiplication and subtraction-division.

4. Research design

Because of the impracticality of conducting a randomized experimental study, a quasi-experiment was designed to evaluate the effectiveness of learning games on students' motivation, interest, and mathematics achievement. It represents a form of intervention research that allows for experimental trials without the random allocation to experimental and control groups (Creswell & Guetterman, 2018; Johnson & Christensen, 2016). Despite its limitations

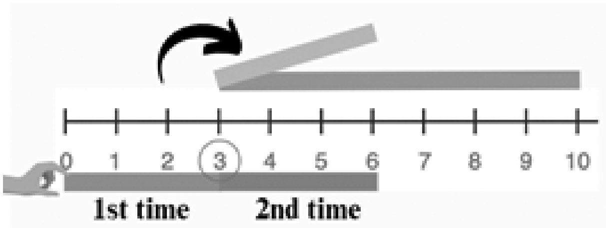

Figure 2. Folding 3 by 2 times, result: 6

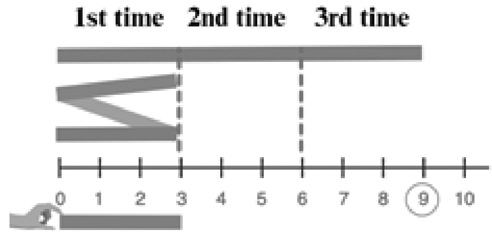

Figure 3. Reducing 9 by 3 times, result: 3

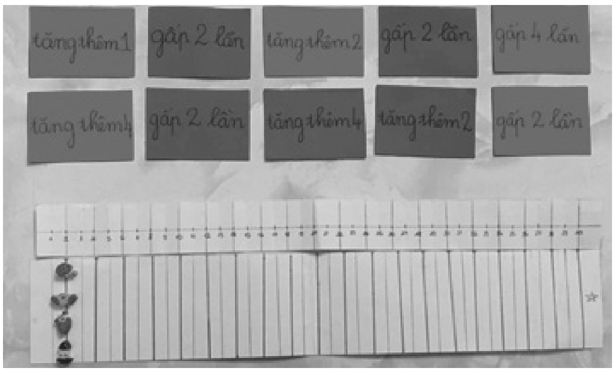

Figure 4. Game "Magical Tape"

compared to randomized controlled trials, this research design remains effective in providing optimal causal relationships regarding the educational impacts of learning games, which are of interest to us. Although it offers a lower quality of evidence than randomized controlled trials, this study still provides more substantial evidence than observational studies (Creswell & Guetterman, 2018). For comparing the control and experimental groups, we chose the pre-test and post-test design for the effectiveness of measuring outcomes (Johnson & Christensen, 2016).

4.1. Participants

The study was conducted on 208 students across six third-grade classes in a public primary school in District 7, Ho Chi Minh City, during the 2023-2024 academic year. Three of the six classes were ramdonly selected to form the Experimental Group (EG) (including 104 students), and another the three remaining classes are the Control Group (CG) (including 104 students). Each class had an average of 34 students. It was not possible to randomize students within each class, so this is not a true-experimental, but only the quasi-experimental design.

4.2. Procedure

The experimental process is summarized in Figure 5. The duration of the experiment extended over three weeks, encompassing five classes. In the first session, students from six classes were invited to complete pre-tests, including a math motivation survey and a baseline math knowledge test, which are described in the 4.3 part.

In the subsequent two sessions, students were taught the topics "Multiplying a Number by a Number" and "Reducing a Number by a Number" by their class teachers. Through the examination of lesson plans and consultations with teachers instructing in CG, it observed that students within these groups engage in conventional learning methodologies, utilizing textbooks, following to instructor-led directives through television presentations, and responding to open-ended question to formulate new mathematical concepts. In contrast, the EG was engaged in a gaming experience, reinforcing their lessons through the use of learning games.

Finally, both groups underwent two surveys assessing their mathematical motivation and a post-test covering the aforementioned topics. This structured approach aimed to compare the effectiveness of traditional teaching methods against the innovative use of learning games in enhancing mathematics academic performance and student motivation.

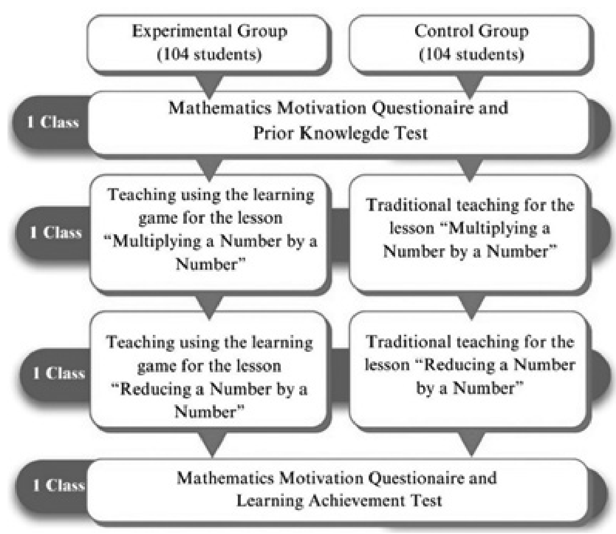

Figure 5. Experimental Process

4.3. Instruments

This study utilized two tools for quantitative data collection: two Performance Assessment Tests (pre-test and post-test), and a Mathematics Motivation Questionnaire.

The performance assessment tests were designed to evaluate students' knowledge in selecting appropriate mathematical operations to represent scenarios presented in practical mathematics problems. The pre-test focused on assessing the ability to recognize and correctly apply the four basic operations. This assessment comprised 17 questions, including 5 addition, 5 subtraction, 4 multiplication, and 3 division problems. Subsequently, the post-test knowledge assessment aimed to evaluate the ability to solve problems related to the practical significance of operations, simple comparative relationships, and the distinction between multiplication (increasing by a multiple) and addition (increasing by a sum), as well as between division (decreasing by a multiple) and subtraction (decreasing by a difference). This test included 25 questions: 7 addition, 5 subtraction, 7 multiplication, and 6 division problems. Both tests were timed at 35 minutes, with a maximum score of 10 points. The questions were arranged in increasing order of difficulty. The test is designed to ensure that the content meets the required standards and is suitable for students. Notably, the post-experimental performance test was reviewed and considered appropriately challenging by a teacher at that school. It also received constructive feedback and development input from the head teacher of grade 3 at Dinh Bo Linh Elementary School, who possesses over 20 years of teaching experience. This collaborative approach ensured the test's relevance and educational value.

To measure students' motivation, we adopted The Mathematics Motivation Questionnaire, as proposed by Kebritchi, an instrument comprising 20 items, employing a Likert scale that ranges from 1 (Strongly Disagree) to 5 (Strongly Agree). This tool is designed to assess the motivational attitudes of students toward learning mathematics. It includes statements such as "I believe that I will enjoy this mathematics class so much that I would like to know more about this topic" and "I do not think that this course will be worth my time and effort." The widespread application of this questionnaire in a variety of research studies has been noted, indicating its significant reliability in this field. Furthermore, the internal consistency of the questionnaire, as measured by Cronbach's Alpha, was empirically validated for pretest (α=0.87, n=499) and the posttest (α=0.86, n=641) (Kebritchi et al., 2010). In addition, the credibility of the Mathematics Motivation Questionnaire has been acknowledged in additional scholarly works, notably by (Girard et al., 2013; Jääskä et al., 2022). The items were translated into Vietnamese and rewritten simply for the participants who were only around eight years old. Some items difficult for 3rd graders to understand were removed, so the final scale used in this study only comprises 12 items, with α= 0.771 for the pre-test and α= 0.784 for the post-test (n= 208), which is still greater than 0.7, so the scale is still reliable.

The research employed IBM SPSS Statistics 26 software to analyze quantitative data, employing Independent T-tests and Paired Samples T-tests. The Independent T-test was utilized to compare mean values of mathematics test scores and motivation between two groups before and after the intervention, which is crucial for assessing the intervention's effectiveness by analyzing group mean score differences. The Paired Samples T-Test compared mathematics motivation between groups after a two-week experimental period, which is ideal for assessing changes within groups over time when measuring the same subjects before and after an intervention.

5. Results

5.1. Test performance

Table 5 shows that, at the pre-test, students in the EG achieved a mean score of 7.433. Additionally, those in the CG obtained corresponding values of 7.442. Levene's test revealed equal variances within groups (F = 0.008, Sig. = 0.930 > 0.05). Moreover, the significance level (Sig.) of the T-Test is 0.962, which is greater than 0.05. Consequently, the Independent t-test indicates no significant difference in learning achievement between the two groups before experimenting.

In terms of the post-test result, Table 5 indicates that students in the EG achieved a mean score of 7.606, while those in the CG obtained corresponding values of 7.207. Levene's test confirmed equal variances within the groups (F = 1.264, Sig. = 0.262 > 0.05). Furthermore, the significance level (Sig.) of the T-Test is 0.045, which is lower than 0.05. This indicates that the EG has a significantly higher average score than the CG.

Table 5. Comparison of the mathematics test performance for the two groups

	Group	Mean	Standard deviation (SD)	Sig.
Pre-intervention	EG	7.433	1.4449	0.962
	CG	7.442	1.4503	
Post-intervention	EG	7.606	1.4742	**0.045**
	CG	7.207	1.3840	

5.2. Mathematics motivation

Table 6 indicates that before the intervention, students in the EG scored an average of 3.922 in mathematics motivations, while those in the CG achieved corresponding values of 3.932. Furthermore, the significance level (Sig.) of the T-Test is 0.910, exceeding 0.05. Consequently, the independent sample t-test suggests no significant difference in motivation between the two groups before the experiment.

After the intervention, according to Table 6, the mean score for students in the EG was 4.234, whereas those in the CG achieved corresponding values of 4.024. Moreover, the significance level (Sig.) of the T-Test is 0.008, which is below 0.05. This implies that the EG has a statistically significantly higher average score than the CG.

Table 6. Comparison of the mathematics motivation for the two groups

	Group	Mean	SD	Sig.
Pre-intervention	EG	3.922	0.5992	0.910
	CG	3.932	0.6732	
Post-intervention	EG	4.234	0.4671	**0.008**
	CG	4.024	0.6425	

To investigate the development of motivational aspects after the periods, a Paired samples t-test was conducted. The results showed a significant increase in the scale scores for the EG (3.922 to 4.234, Sig. = 0.000 < 0.05), indicating a statistically significant improvement. Conversely, for the CG, the average confidence and interest in mathematics did not show a statistically significant difference (3.932 to 4.024, Sig. = 0.316 > 0.05).

Table 7. Comparisons of the changes in mathematics motivation for the two groups before and after the intervention

	Pair	SD	Sig.
Pair 1	Post EG - Pre EG	0.7469	**0.000**
Pair 2	Post CG - Pre CG	0.9327	0.316

6. Discussion

The findings substantiate the assertion that the integration of educational games into the learning process enhances the students' engagement and knowledge acquisition. This approach fosters an enjoyable and significant learning context, which in turn augments student outcomes, and motivation in mathematics lessons.

The first question aimed to examine the effect of a learning game regarding the learning outcomes of selected mathematical content in the experiment. The results show that in terms of the post-test scores, the EG scored higher than the CG, proving its effectiveness in enhancing math performance. When analyzing level 3 questions in the test in the form of choosing operations corresponding to real-life situations, the students in the EG showed a higher correct rate (66.15%) compared to the CG (31.62%). This explains the score difference mentioned above. The results affirm that both groups met the required learning objectives of the lesson; however, the experimental group demonstrated a deeper understanding of the concepts of multiplication and division. Thus, learning through games has helped students in the experimental group apply the essence of multiplication and division. In contrast, the CG engaged in traditional teaching methods, where teachers posed open-ended questions and used textbooks to guide students. This approach led the students in this group to understand the concepts in a simplistic manner, without a clear understanding of the rationale and significance behind mathematical operations, resulting in confusion and errors when faced with different exercises. Explaining this, Tran (1999) mentioned that while playing, children have the opportunity to use their senses, language, and to analyze, synthesize, compare, categorize, and generalize, thereby, through educational games, children grasp and deeply engrave various knowledge, concepts, and symbols about the systematic world around them. However, we believe that attention should be paid to the issue of designing game rules and playing operations so that they are both simple and competitive to stimulate psychology and interest, leading to easier knowledge formation. Indeed, a study by two authors from the United Kingdom, Sala and Gobet (2017), showed no difference in computational ability and mathematical cognition between CG and EG.

For the second research question, the findings reveal that incorporating learning games, especially in math classes, fosters positive emotions such as excitement. This approach helps children build confidence, become more self-aware in both individual and group work, and develop a cooperative spirit for completing tasks and engaging in activities. The results show a progressive increase in motivation among students in the EG, with their initial motivation level significantly rising. The study also notes that games fulfill children's needs for physical activity, cooperation, and communication with peers, leading to active participation and positive emotions such as enthusiasm and joy. This aligns with the research conducted by Pham Tien Thanh and Pham Thi Tham, underscoring the value of games in addressing students' psychological characteristics (Pham, 2018; Pham, 2017). Furthermore, Sousa et al. (2023) agree with these findings, highlighting motivation and confidence as positive outcomes of games.

Besides, by observing three experimental classes, we affirm that students responded positively to the classroom activities, especially the educational games, indicating that integrating games into teaching fosters a more engaging learning environment. Observations during activities such as “Magical tape” and “Arrange evenly” showed that students could grasp new mathematical concepts, like multiplication and distribution, through hands-on experiences. Moreover, during concluding reinforcement activities, students exhibited increased interest and motivation towards Mathematics, highlighting the effectiveness of group-based practice facilitated by educational games in making learning more enjoyable and proactive.

7. Conclusion

This study proposes an approach to engage third graders in constructing mathematics knowledge by using games based on Experiential Learning Theory. It suggested that our designed learning games provided an environment for children to experience and reflect on knowledge. The learning games are designed to be simple and cost-effective, thus enabling teachers and students to easily prepare for and apply them in practice. The game integrates a combination of the framework in Appendix 3 - Official Dispatch 2345 (Ministry of Education and Training, 2021) and the four-step process in David Kolb's experiential learning model. This is advantageous for developing lesson plans that are not only familiar to primary teachers but also make the learning process more enjoyable and engaging for students. The experimental evaluation session was conducted in two groups to verify the effectiveness of the proposed method. To sum up, this study presents a more engaging teaching approach in Mathematics to support students in the process of forming new knowledge and applying it in practical classroom contexts.

The study presents several noteworthy limitations. Firstly, constrained by resources, a random selection of students was not feasible. Consequently, students from six classes were invited to participate in an initial knowledge and math motivation assessment, leading to the selection of three experimental classes. Secondly, the application of learning games was limited to two lessons per class, potentially fostering only an initial interest among students. This highlights the necessity for more extensive, longitudinal research in the future. Furthermore, beyond imparting knowledge and skills, the study underlines the importance of cultivating core values of motivation and interest, an area where learning games demonstrate considerable potential. Future research should endeavor to employ random sample selection and expand the variety of learning games used in order to more accurately assess their effectiveness. Additionally, there is an opportunity for researchers to develop a diverse array of games tailored to the content of grades 4 and 5, particularly in the context of the new mathematics curriculum, where current research is sparse.

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