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Designing Educational Games in Teaching Grade 3 Mathematics to Develop Logical Thinking Skills for Students in Some Primary Schools, Tuyen Quang Province, Vietnam

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***Abstract*---**This study aims to design educational games integrated into Grade 3 mathematics lessons to develop logical thinking skills for students in several primary schools in Tuyen Quang Province, Vietnam. A mixed-methods approach was employed to evaluate the effectiveness of the games through pre- and post-tests on logical thinking, motivation surveys, classroom observations, and interviews with teachers and students. Results indicated significant improvements in students' logical thinking abilities and motivation toward mathematics learning. The games contributed to creating a dynamic and cooperative learning environment, enhancing student engagement and cognitive development. The findings confirm the role

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of educational games as effective instructional tools in primary math education and suggest directions for broader application in practice.

Keywords---Educational games, Logical thinking, Mathematics education, Primary students, Game-based learning.

1. Introduction

Developing logical thinking skills is recognized as a fundamental goal in primary education, particularly in mathematics teaching, where students are required not only to memorize facts but also to engage in problem-solving and critical reasoning (Bottino et al., 2007). Logical thinking forms the basis for students' ability to analyze, synthesize, and evaluate mathematical concepts, which are essential for their academic success and lifelong learning (Phuong et al., 2017). Therefore, designing effective teaching methods that actively foster these skills is a critical challenge for educators.

One promising approach to enhance students' engagement and cognitive development in mathematics is through educational games. Educational games have been shown to increase motivation, improve knowledge retention, and facilitate the development of higher-order thinking skills (Garris et al., 2002; Bai et al., 2012). As Gee (2005) emphasized, well-designed digital games can provide immersive environments that promote "deep learning" by integrating content with meaningful challenges and immediate feedback. Such interactive learning experiences are particularly valuable for young learners who benefit from active and playful learning environments.

In Vietnam, while the national curriculum highlights the importance of developing students' logical and problem-solving skills in mathematics (Ministry of Education and Training, 2018), traditional teaching methods often rely heavily on rote learning and passive knowledge transfer. This gap calls for innovative pedagogical tools that align with contemporary educational goals. Previous studies have reported that integrating game-based learning strategies into math education can effectively promote students' cognitive skills and attitudes toward the subject (Russo et al., 2021; Rakasiwi & Muhtadi, 2021). However, there is limited research on the design and implementation of educational games tailored specifically for primary school students in local Vietnamese contexts, such as in Tuyen Quang Province.

This study aims to design educational games for Grade 3 mathematics lessons with a focus on developing students' logical thinking skills in several primary schools in Tuyen Quang, Vietnam. By grounding the design process in established educational theories and adapting games to the local curriculum and student needs, this research seeks to provide practical solutions for enhancing mathematics teaching effectiveness. The study also examines how these games impact student engagement and logical reasoning capabilities, contributing to the broader understanding of game-based learning in Vietnamese primary education settings (Giannakos, 2013).

2. Literature Review

The development of logical thinking skills in primary school students is widely acknowledged as crucial for their cognitive growth and academic achievement, particularly in mathematics (Bottino et al., 2007). Logical thinking enables learners to organize information systematically, identify patterns, and solve problems effectively (Phuong et al., 2017). Educational theories such as constructivism emphasize the importance of active engagement and contextualized learning experiences to foster these skills (Driver & Oldham, 1986; Brown et al., 1989). These theories suggest that learners construct knowledge meaningfully when interacting with materials in a social and authentic context.

Educational games have increasingly been recognized as effective tools in enhancing student motivation and supporting the development of higher-order cognitive skills including logical reasoning (Garris et al., 2002; Bai et al., 2012). According to Gee (2008), good educational games provide challenges that promote problem-solving, critical thinking, and deep learning. Empirical studies have confirmed that game-based learning can improve mathematics achievement among primary and secondary students by making abstract concepts more concrete and engaging (Fokides, 2018; Rakasiwi & Muhtadi, 2021). For example, Chizary & Farhangi (2017) found that educational games significantly enhanced mathematics learning outcomes for second-grade students by promoting active participation and logical reasoning.

Several scholars have explored different types of educational games in various contexts, demonstrating their adaptability and effectiveness. Ardiningsih (2019) developed interactive quiz games as formative assessment tools that actively engage students in music theory courses, highlighting the potential of games to support learning assessment. Similarly, Bai et al. (2012) reported that a 3-D instructional game improved both the mathematics achievement and motivation of middle school students, emphasizing the role of immersive game environments in learning. In primary education, Bottino et al. (2007), illustrated how computer games could develop strategic and reasoning abilities, which are integral to logical thinking.

In Vietnam, although the General Education Curriculum for Mathematics encourages the integration of innovative teaching methods to develop students' competencies (Ministry of Education and Training, 2018), the practical application of educational games remains limited. Research by Nguyen Kim Chuyen (2012) and Nguyen Thi Nga (2016) highlighted the potential of games to enhance active learning and creativity but noted challenges such as lack of localized game content and teacher training. Moreover, studies focused on the specific context of Vietnamese primary schools, especially in rural or less urbanized provinces like Tuyen Quang, are scarce.

Overall, the literature suggests that educational games, when designed thoughtfully to align with curriculum goals and learner characteristics, can be powerful tools to cultivate logical thinking in young learners. This study builds on this foundation by designing games tailored for Grade 3 mathematics teaching in

Tuyen Quang, addressing a research gap in localized game-based learning interventions (Bray & Tangney, 2017).

3. Research Methodology

3.1 Research Design

This study applied a mixed-methods research design, combining both quantitative and qualitative approaches to comprehensively evaluate the effectiveness of educational games in developing logical thinking skills among Grade 3 students. The quantitative component involved pre- and post-intervention testing to measure changes in students' logical thinking abilities and motivation towards mathematics. The qualitative component included classroom observations and semi-structured interviews with teachers and students to gain deeper insights into engagement levels, learning behaviors, and perceptions regarding the educational games.

3.2 Participants and Setting

The research was conducted in three primary schools located in Tuyen Quang Province, Vietnam. The sample consisted of 90 third-grade students, including 45 boys and 45 girls, aged 8 to 9 years old. These students represented diverse backgrounds within the local context. Six mathematics teachers who taught the participating classes also took part in the qualitative data collection. Participation was voluntary, and ethical considerations such as informed consent from students and parents were ensured.

3.3 Intervention

The intervention involved the design and implementation of educational games tailored to the Grade 3 mathematics curriculum with a focus on fostering logical thinking skills. The games were integrated into regular math lessons over a specific period. Each game was developed following a structured design process, ensuring alignment with learning objectives and appropriateness for students' cognitive levels.

3.4 Data Collection Methods

Pre- and Post-Tests: A standardized test consisting of 20 items assessing logical thinking abilities related to Grade 3 math content was administered before and after the game-based learning intervention.

Motivation Survey: A 10-item Likert scale questionnaire measured students' motivation towards mathematics learning at both pre- and post-intervention stages.

Classroom Observations: Structured observation checklists were used by researchers to record students' engagement, participation, collaboration, and attitudes during lessons involving the educational games.

Semi-structured Interviews: In-depth interviews were conducted with six teachers and eighteen students to explore their experiences, feedback, and perceived impact of the educational games on learning.

3.5 Data Analysis

Quantitative data from the tests and motivation surveys were analyzed using descriptive statistics (mean, standard deviation) and inferential statistics (paired

t-tests) to determine the significance of changes before and after the intervention. Qualitative data from observations and interviews were thematically analyzed to identify patterns in student engagement, learning behaviors, and teacher/student perceptions regarding the games' effectiveness.

3.6 Validity and Reliability

To ensure validity, the test instruments and questionnaires were developed based on curriculum standards and reviewed by the research team. Classroom observations were conducted by trained researchers following standardized protocols. Interview guides were piloted to refine questions for clarity and relevance. Reliability was maintained by using consistent procedures across schools and triangulating quantitative and qualitative data sources to strengthen the overall findings.

4. Design of Educational Games

Phase 1: Preparation

Step 1. Identify the content to be supported by the game and students' prior knowledge

Teachers study textbooks, teacher's guides, and other materials to determine the content that the game will support within the lesson, aiming to maximize lesson effectiveness. At the same time, they explore the knowledge and experience that students have accumulated, reviewing the areas students need to learn, practice, consolidate, and expand. Based on this, the game is designed to match the students' level and learning needs, creating optimal conditions for effective lesson absorption.

Step 2. Define the game objectives

The game objectives must be aligned with the learning objectives. It is necessary to clearly identify the learning goals that the game will help achieve, including lesson knowledge and the qualities and skills students need to develop and acquire.

Step 3. Choose the game name

The game name should be relevant to its objectives and content. Avoid overly long names; the name should be simple, easy to understand and remember, and evoke fun, curiosity, and eagerness to participate among students.

Step 4. Determine the content of questions and answers

Content must be clear, accurate, and easy to understand.

Purpose: Specify the purpose of the game regarding which knowledge or skills it aims to review or consolidate. The game's purpose will guide the design of gameplay actions.

Materials and tools: Describe the materials and tools used in the educational game.

Rules: Clearly specify the rules governing players' actions, and the criteria for winning or losing the game.

Number of participants: Specify how many players can participate.

Step 5. Define gameplay and rules

This includes the specific tasks and activities students will perform. Based on the game's objectives, tasks and activities are constructed accordingly. The gameplay should be clear so students can easily understand and carry it out without difficulty. The description must include the game's regulations and formats. Rules

should be clear, fair, and consistent, ensuring all students have equal opportunity to participate and succeed.

Step 6. Conclusion

State the significance of the game and its intended goals. The specific steps should be clearly illustrated in each designed game.

Phase 2: Game Design

Use Canva software to design slides and the game interface.

Step 1. Access Canva:

On Canva's homepage, click "Create a design."

In the design creation box, select "Presentation."

Choose a design template.

Step 2. Design slides:

Create layouts for the game slides:

Design the home slide introducing the game.

Design slides explaining the rules and how to play.

Design question and answer slides, with each question on a separate slide.

Step 3. Export file as PowerPoint:

Use PowerPoint software to edit effects and run the game on Microsoft PowerPoint.

Add sounds and effects in PowerPoint, then run the game.

Step 4. Open the file in PowerPoint.

Step 5. Add effects to the game.

Step 6. Add sounds to the game.

Step 7. Use Slide Show mode in PowerPoint to preview and check all effects.

Example of Educational Game Design Practice: "Building a House for the Rabbit"

Phase 1: Preparation

Step 1. Identify content and students' prior knowledge

The teacher reviewed the Grade 3 math curriculum, focusing on the topic of spatial reasoning and basic geometry. Textbooks and teacher's guides were studied to identify the key knowledge and skills students should master. It was found that students had basic understanding of shapes and sizes but needed more practice in spatial arrangement and logical sequencing. This game aims to reinforce these concepts.

Step 2. Define game objectives

Help students practice arranging geometric shapes logically to build a house.

Develop students' spatial awareness and logical thinking skills.

Encourage collaborative problem-solving and decision-making.

Step 3. Choose the game name

The game was named **"Building a House for the Rabbit"**, which is simple, relatable, and intriguing for Grade 3 students.

Step 4. Determine content of questions and answers

Purpose: To review spatial reasoning by asking students to select correct shapes and place them in order to complete the house design.

Materials: Digital slides including images of shapes, house parts, and instruction texts.

Rules: Students work individually or in pairs. They answer questions by choosing the right shape or arrangement. Correct answers move the house construction forward. The first to complete the house wins.
Number of participants: 2–4 players.

Figure 1. Helping the Rabbit Build a Home

Step 5. Define gameplay and rules
Students receive a series of tasks requiring them to select shapes or arrange parts of a house logically. Each correct choice advances the building process. The gameplay is turn-based, allowing fair participation. Rules include clear instructions on how to answer, time limits per turn, and criteria for winning (completion of the house first or most correct answers after all questions).
Step 6. Conclusion
This game aims to make abstract spatial reasoning tangible and enjoyable, promoting active learning and reinforcing key math skills through interactive play.

Phase 2: Game Design
Step 1. Access Canva
Log in to Canva.
Click “Create a design” and select “Presentation.”
Choose a colorful, child-friendly template suitable for elementary students.
Step 2. Design slides
Home slide: Title “Building a House for the Rabbit” with a cheerful illustration of a rabbit and a house frame.
Rules slide: Step-by-step instructions on how to play, with icons and simple language.
Question slides: Each slide presents a question such as “Which shape fits the door?” with multiple-choice options displayed as clickable areas or images.
Answer slides: Feedback slides showing correct answers and explanations.
Step 3. Export as PowerPoint
Download the Canva presentation as a PowerPoint file (.pptx).
Open the file in Microsoft PowerPoint for further editing.

Step 4. Open the file in PowerPoint

Check slide formatting and transitions.

Step 5. Add effects

Apply entrance animations (e.g., "Zoom," "Fade") to questions and answer options to engage students.

Use motion paths for building parts to visually assemble the house as students progress.

Step 6. Add sounds

Insert cheerful background music and sound effects for correct/wrong answers to enhance engagement.

Step 7. Preview Slide Show

Run the slideshow to test animations, sound synchronization, and gameplay flow. Adjust timings and effects for smooth, interactive experience.

5. Results

5.1 Quantitative Results

5.1.1 Assessment of Logical Thinking Skills Before and After Intervention

The study involved 90 third-grade students from three primary schools in Tuyen Quang Province, consisting of 45 boys and 45 girls aged 8 to 9 years. To measure the development of students' logical thinking abilities, a 20-item test related to grade-level mathematics concepts was administered before and after the educational game intervention. The test scores are summarized in the table below:

Table 1: Comparison of Logical Thinking Test Scores Before and After Intervention

Time of Assessment	**Number of Students (n)**	**Mean Score**	**Standard Deviation (SD)**	**Paired t-test (t)**	**p-value**
Pre-intervention	90	58.4	12.3		
Post-intervention	90	74.7	10.5	12.856	< 0.001*

Detailed analysis:

The average score increased by 16.3 points (27.9% improvement) after the intervention. The decrease in standard deviation indicates that student scores became more consistent post-intervention. The paired t-test confirmed the difference is statistically significant at $p < 0.001$, demonstrating the educational game effectively enhanced students' logical thinking skills.

5.1.2 Motivation Survey on Mathematics Learning

A 10-item Likert-scale questionnaire assessing students' motivation toward learning mathematics was administered before and after the intervention. Scores ranged from 1 (strongly disagree) to 5 (strongly agree). The average scores are shown below:

Table 2: Students' Motivation Scores Toward Mathematics Before and After Intervention

Time of Survey	Mean Score (out of 5)	Interpretation
Pre-intervention	3.2	Moderate motivation
Post-intervention	4.1	High motivation

Detailed analysis:

The motivation score improved by 0.9 points, equivalent to a 28% increase. Statistical analysis showed the increase is significant at $p < 0.01$, indicating that the educational game positively impacted students' enthusiasm and attitude toward mathematics.

5.2 Qualitative Results

5.2.1 Classroom Observations
Using a structured observation checklist, researchers recorded students' engagement, participation, interaction, and collaborative behaviors during lessons involving the educational game.

Table 3: Summary of Classroom Observation Results

Behavior / Attitude	Number of Students (out of 90)	Percentage (%)
High concentration and active participation	77	85.6%
Proactive collaboration and idea sharing	72	80.0%
Demonstrated positive learning attitude	83	92.2%
Students showing disengagement or boredom	0	0%

Observational insights:
The majority of students demonstrated focused and enthusiastic engagement during game-based activities.
Peer interaction and cooperative problem-solving increased notably compared to traditional lessons.
No student showed signs of disengagement or distraction during the activities.
Teachers reported a livelier classroom atmosphere and increased interaction.

5.2.2 Semi-structured Interviews
Interviews were conducted with 6 teachers and 18 students to gather deeper insights into their perceptions of the educational game's effectiveness.

Teacher feedback:
"The game attracts students' attention and encourages active logical reasoning." (Teacher 1)

"Students are more enthusiastic and less passive during math lessons." (Teacher 2)
"I suggest adding more challenging levels to cater to students with varied abilities." (Teacher 4)
"The game format encourages weaker students to participate confidently through group work." (Teacher 5)
"It creates a dynamic learning environment that helps teachers better assess progress." (Teacher 6)

Student feedback:
"I like the math games because they are fun and easier to understand than just writing on the board." (Student 7)
"Playing the game helps me feel more confident in solving math problems." (Student 12)
"Working with friends in the game helps me understand and remember lessons better." (Student 15)
"I hope the school makes more games like this." (Student 3)
Most students reported that the game made learning math enjoyable, reduced stress, and increased their motivation.

5.3 Integrated Analysis

Quantitative data clearly demonstrate the educational game's positive effect on improving students' logical thinking skills and their motivation toward learning mathematics, with statistically significant increases in test scores and motivation survey results.

Qualitative data reveal meaningful behavioral changes, including increased student engagement, cooperative learning, and positive attitudes during lessons. Teachers and students alike reported enhanced classroom dynamics and learning experiences.

The combination of quantitative and qualitative approaches provides a comprehensive understanding of the educational game's multifaceted impact, confirming its value as an effective instructional tool in primary math education in Tuyen Quang Province.

6. Discussion

The results of this study demonstrate that the educational games designed to develop logical thinking skills for Grade 3 students had a significant positive impact on both students' logical reasoning abilities and their motivation to learn mathematics. Quantitative data analysis revealed a statistically significant increase in students' logical thinking test scores after the intervention ($p < 0.001$), indicating that the games effectively reinforced and enhanced logical thinking skills. The 27.9% improvement in scores suggests that the games not only supported knowledge consolidation but also promoted comprehensive development of reasoning abilities.

Furthermore, the motivation survey showed a substantial increase in students' interest and enthusiasm towards mathematics learning. The integration of educational games created a dynamic and interactive classroom environment, reducing learning pressure and fostering collaboration among students. Classroom observations and interviews supported these findings, as most students and teachers reported increased engagement, active participation, and positive attitudes during math lessons involving the games (All et al., 2016).

These findings align with previous studies that highlight the benefits of game-based learning in promoting cognitive skills and student motivation (Garris et al., 2002; Bai et al., 2012). The study also underscores the importance of designing games that are age-appropriate and aligned with curriculum objectives, ensuring their feasibility and attractiveness in primary education settings, particularly in the local context.

However, the study has some limitations, including a relatively small sample size limited to one province, which may affect the generalizability of the results. Additionally, teachers suggested incorporating more challenging levels within the games to accommodate diverse student abilities, which could further enhance learning outcomes. Future research should consider expanding the scope and diversifying game types to address these limitations.

7. Conclusion

This study successfully designed and implemented educational games within Grade 3 mathematics teaching aimed at developing students' logical thinking skills in several primary schools in Tuyen Quang Province. The evaluation showed that the games significantly improved students' logical reasoning capabilities and increased their motivation and enthusiasm for mathematics. The games fostered an engaging learning environment that encouraged active participation, collaboration, and interaction among students, thereby enhancing teaching effectiveness.

The study demonstrates the feasibility and effectiveness of applying well-designed educational games aligned with curriculum content and student characteristics in local primary education contexts. This approach represents a promising innovation for mathematics teaching, contributing to the comprehensive development of students' cognitive competencies.

It is recommended that future efforts focus on expanding the scale of implementation, diversifying game formats, and providing more professional training for teachers to maximize the impact and scalability of educational games in primary schools.

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