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Teaching Grade 6 Mathematics Towards Developing Students' Mathematical Communication Competence Through Learning Games with the Support of Digital Tools

Nguyen Thi Huong Lan

Faculty of Education, Tan Trao University, Tuyen Quang Province, Vietnam

Corresponding author email: NTHLan@tqu.edu.vn

Ma Thi Mai

Mathematics Teacher Education B, Cohort 2023–2027, Faculty of Education, Tan Trao University, Tuyen Quang Province, Vietnam

Ma Thuyen Thu

Mathematics Teacher Education B, Cohort 2023–2027, Faculty of Education, Tan Trao University, Tuyen Quang Province, Vietnam

Hoang Van Dan

Mathematics Teacher Education B, Cohort 2023–2027, Faculty of Education, Tan Trao University, Tuyen Quang Province, Vietnam

Abstract---*The results of the study indicate that students' mathematical communication competence improved after the implementation of lessons integrating learning games and digital tools. The increase is evident not only in test scores but also in classroom behavior, where students participated more actively, explained their thinking more clearly, and engaged more frequently in discussion. What stands out is not just the level of improvement, but the way it happened. When students were placed in situations that required interaction, supported by tools that allowed everyone to participate, communication became a natural part of learning rather than a separate objective. This suggests that developing communication competence depends heavily on how learning activities are designed. The findings provide a practical direction for teaching mathematics in lower secondary education. Integrating game-based activities with digital tools can create a learning environment that encourages students to express ideas, listen to others, and refine their thinking through interaction. At the same time, the study was limited to one group of 65 students and a relatively short intervention period. Further work could extend the duration, involve more schools, or compare different teaching approaches to better understand long-term effects. Even with these limitations, the findings still offer useful initial evidence that this approach can be applied effectively in the context of Tuyen Quang province.*

Keywords---*Teaching Grade 6 Mathematics, Mathematical Communication Competence, Learning Games, Support of Digital Tools.*

Introduction

In recent years, educational reforms worldwide have emphasized a shift from knowledge transmission to competency-based learning, aiming to develop learners' essential skills for the twenty-first century. In Vietnam, this transformation is clearly reflected in the 2018 General Education Curriculum, which highlights the importance of developing students' competencies and qualities, particularly in core subjects such as mathematics ([Ministry of](#)

[Education and Training, 2018a](#)). Mathematics is not only a foundational discipline for logical thinking but also plays a crucial role in equipping students with problem-solving and communication skills necessary for real-life situations ([Tran, 2020](#)).

Among the key competencies in mathematics education, mathematical communication competence has gained increasing attention in both research and practice. According to the National Council of Teachers of Mathematics, mathematical communication involves the ability to express ideas clearly, analyze others' reasoning, and use appropriate mathematical language to convey understanding ([National Council of Teachers of Mathematics, 2000](#)). Similarly, researchers have emphasized that communication is central to learning mathematics, as it enables students to articulate reasoning, justify solutions, and engage in meaningful discourse ([Pourdavood & Wachira, 2015](#)). In the Vietnamese educational context, this competence includes skills such as explaining mathematical ideas, participating in discussions, and using symbols and representations effectively ([Ministry of Education and Training, 2018b](#)).

Despite its importance, the development of mathematical communication competence in lower secondary education, particularly at Grade 6, remains limited. Many students tend to focus primarily on obtaining correct answers rather than explaining their reasoning or engaging in discussion. Classroom practices are often still dominated by teacher-centered approaches, where opportunities for students to communicate mathematically are insufficient. As a result, students frequently lack confidence in presenting their ideas, have difficulty using mathematical language, and rarely participate in argumentation or peer discussion ([Pham et al., 2022](#)). These challenges are especially evident during the transition from primary to lower secondary education, where students encounter more abstract mathematical concepts and require stronger communication skills to support understanding.

To address these limitations, innovative teaching approaches are necessary. One promising direction is the integration of game-based learning into mathematics instruction. Learning games create interactive and engaging environments that encourage active participation, collaboration, and communication among students. Previous studies have shown that game-based learning can enhance motivation, improve learning outcomes, and foster cognitive as well as affective development ([Hui & Mahmud, 2023](#); [del Moral Pérez & Guzmán Duque, 2018](#)). In mathematics classrooms, games provide natural contexts for students to explain their thinking, negotiate meaning, and respond to peers' ideas.

In addition, the rapid development of digital technology has opened new opportunities for transforming mathematics education. Digital tools such as GeoGebra, Quizizz, and Kahoot enable visualization, interaction, and real-time feedback, thereby making abstract concepts more accessible and promoting student engagement. Importantly, digital tools have been identified as authentic mediators of mathematical communication, as they facilitate interaction, representation, and collaborative learning ([Goos & Sakurai, 2023](#)). Research also indicates that the use of digital tools in mathematics education can significantly enhance students' communication skills by providing multiple ways to express and share ideas ([Uchima-Marin et al., 2021](#); [Delima & Elfandi, 2022](#)).

Although both game-based learning and digital tools have demonstrated positive impacts individually, their combined use in developing mathematical communication competence, particularly for Grade 6 students, has not been sufficiently explored in the Vietnamese context. This gap highlights the need for research that integrates these two approaches into a coherent pedagogical model.

Therefore, this study aims to investigate the effectiveness of teaching Grade 6 mathematics through learning games supported by digital tools in developing students' mathematical communication competence. Specifically, the study seeks to (i) examine the current situation of mathematical communication in mathematics classrooms, (ii) design and implement game-based learning activities with digital support, and (iii) evaluate their impact on students' communication skills. The findings are expected to contribute to both theoretical and practical aspects of mathematics education, particularly in the context of educational innovation and digital transformation ([Fredriksdotter et al., 2022](#)).

Literature Review

Mathematical Communication Competence

Concept of Mathematical Communication

Mathematical communication is widely recognized as a fundamental component of mathematical proficiency and plays a central role in contemporary mathematics education. According to the National Council of Teachers of Mathematics, mathematical communication refers to students' ability to express mathematical ideas clearly, analyze and evaluate the reasoning of others, and use appropriate mathematical language to convey understanding ([National](#)

[Council of Teachers of Mathematics, 2000](#)). This competence is not only a tool for sharing knowledge but also a means through which students construct and deepen their mathematical thinking.

From a broader perspective, mathematical communication encompasses various forms of representation, including spoken and written language, symbols, diagrams, graphs, and other visual models. It enables learners to connect abstract mathematical concepts with meaningful contexts and supports the development of higher-order thinking skills ([Pourdavood & Wachira, 2015](#)). In competency-based education systems, mathematical communication is considered both a learning objective and an essential process that facilitates knowledge construction.

In Vietnam, the 2018 General Education Curriculum identifies mathematical communication as a core component of mathematical competence. It includes the ability to interpret mathematical information, present ideas logically, and interact with others using appropriate mathematical expressions ([Ministry of Education and Training, 2018a](#)).

Basic Components of Mathematical Communication

Mathematical communication competence can be analyzed through several key components.

The first component is expression, which refers to the ability to clearly present mathematical ideas using appropriate language, symbols, and representations. Students are expected to translate their thinking into understandable forms, including verbal explanations, written solutions, and visual representations.

The second component is reasoning, which involves explaining the logic behind mathematical processes and justifying solutions. This requires students to construct coherent arguments, provide evidence, and connect mathematical ideas systematically. Reasoning is essential for developing a deep understanding and critical thinking.

The third component is interaction and discussion, which focuses on students' participation in mathematical discourse. This includes asking questions, responding to peers, engaging in discussions, and evaluating different solutions. Through interaction, students refine their understanding and develop the ability to communicate mathematical ideas effectively ([Yang & Kaiser, 2022](#)).

Together, these components form an integrated framework that reflects the multifaceted nature of mathematical communication. Research indicates that learning environments that promote discussion and interaction significantly enhance students' communication skills in mathematics ([Goos & Sakurai, 2023](#)).

Game-Based Learning in Mathematics Teaching

Concept of Game-Based Learning

Game-based learning refers to the use of structured games with defined rules and objectives to support learning processes. In educational contexts, learning games are designed to integrate academic content with engaging and interactive activities, allowing students to acquire knowledge and skills in a meaningful way ([del Moral Pérez & Guzmán Duque, 2018](#)).

In mathematics education, game-based learning is particularly effective because it transforms abstract concepts into more concrete and accessible experiences. By embedding mathematical tasks within game scenarios, students are encouraged to explore, experiment, and actively participate in learning activities.



Figure 1. Grade 6 students engaging in game-based mathematics learning with digital tool support

Role in Developing Mathematical Communication

Game-based learning plays a significant role in promoting mathematical communication. First, it creates interactive learning environments where students are required to explain their ideas, justify their reasoning, and collaborate with peers. These interactions naturally foster communication and discourse.

Second, game-based learning enhances student engagement and motivation, which are essential conditions for effective communication. When students are actively involved in learning activities, they are more likely to express their ideas and participate in discussions (Hui & Mahmud, 2023).

Third, games provide authentic contexts for communication, where students must respond to challenges, defend their answers, and reflect on their reasoning. These situations support the development of both expressive and reasoning skills (Loor-Mera & Yáñez-Balarezo, 2022).

Furthermore, research has shown that digital game-based learning can improve students' confidence, reduce anxiety, and increase their willingness to communicate in mathematics classrooms (Hung et al., 2014; Jabbar & Felicia, 2015). Therefore, game-based learning is not only a motivational strategy but also an effective pedagogical approach for developing mathematical communication competence.

Digital Tools in Mathematics Teaching

Role in Supporting Communication and Interaction

The integration of digital tools has significantly transformed teaching and learning processes in modern education. Digital tools are generally defined as technological applications and platforms that support the creation, presentation, and exchange of information in educational contexts (UNESCO, 2019).

In mathematics education, digital tools play a crucial role in enhancing both communication and interaction. They enable students to visualize abstract concepts, represent ideas in multiple forms, and receive immediate feedback. More importantly, digital tools facilitate collaborative learning environments, where students can share ideas, discuss solutions, and engage in meaningful mathematical discourse.

Recent research highlights that digital tools function as mediators of mathematical communication, helping students bridge the gap between abstract concepts and understanding (Goos & Sakurai, 2023). By supporting dynamic representation and interaction, these tools enhance students' ability to express and refine their mathematical thinking.

Examples of Digital Tools

Several digital tools are widely used in mathematics classrooms to support communication and interaction.

One example is Kahoot!, an interactive platform that allows teachers to design real-time quizzes and learning games. Kahoot! promotes active participation and immediate feedback, encouraging students to discuss answers and explain their reasoning.

Another commonly used tool is Quizizz, which provides self-paced, gamified quizzes. Quizizz supports both individual and collaborative learning, enabling students to review content, compare results, and engage in peer discussion.

These tools not only increase engagement but also create meaningful opportunities for students to communicate mathematically through explanation, discussion, and interaction (Meirbekov et al., 2022).

Methodology

Research design

The study combined numerical data with classroom-based evidence to capture both the extent and the nature of changes in students' mathematical communication competence. A pre-test and post-test design was used, in which students' initial results were compared with their performance after the teaching intervention to determine improvement.

Participants

The participants were 65 Grade 6 students from Kim Phu Lower Secondary School, Minh Xuan Ward, Tuyen Quang Province. These students were at the beginning stage of lower secondary education, where the use of mathematical language and reasoning becomes more demanding.

Data collection instruments

Three main tools were used to collect data. A mathematical communication test was administered both before and after the intervention to assess students' ability to present ideas, explain reasoning, and use appropriate mathematical language. A five-point Likert-scale questionnaire was used to gather students' perceptions of engagement, confidence, and participation during learning activities. In addition, classroom observations were conducted to record how students interacted, discussed, and expressed their ideas in mathematical contexts.

Procedure

The process was carried out in three stages. At the beginning, students completed a pre-test to establish their initial level. This was followed by a series of lessons designed with learning games integrated with digital tools such as Kahoot and Quizizz, aiming to increase interaction and encourage students to explain their thinking. At the end of the intervention, students completed a post-test and the questionnaire, while observation notes were collected to reflect the learning process.

Data analysis

The collected data were analyzed using descriptive statistics, mainly mean and standard deviation. Pre-test and post-test results were compared to identify changes in students' competence. Observation data were examined to provide additional insights into students' communication behaviors and participation during the lessons.

Results

Initial situation

The pre-test results indicated that students' mathematical communication competence was generally at a moderate level. Most students were able to provide answers but had difficulty explaining their reasoning clearly or using appropriate mathematical language. Classroom observation at this stage also showed that participation in discussion was limited, and only a small number of students actively expressed their ideas.

Table 1
Pre-test results of mathematical communication competence (n = 65)

Criteria	Mean	SD
Presenting mathematical ideas	2.85	0.64
Explaining reasoning	2.78	0.67
Using mathematical language	2.92	0.61
Participating in a discussion	2.70	0.69
Overall	2.81	0.65

The results show that all components were below level 3.0, indicating that students' communication skills were not yet well developed, particularly in reasoning and discussion.

Post-intervention results

After the implementation of learning games supported by digital tools, students showed noticeable improvement across all aspects of mathematical communication. Students became more willing to share ideas, explain their thinking, and engage in discussions during learning activities.

Table 2
Post-test results of mathematical communication competence (n = 65)

Criteria	Mean	SD
Presenting mathematical ideas	3.68	0.58
Explaining reasoning	3.60	0.62
Using mathematical language	3.72	0.55
Participating in a discussion	3.65	0.60
Overall	3.66	0.59

Compared to the pre-test, all indicators increased to above 3.5, reflecting a clear improvement in students' competence.

Comparison of changes

A comparison between pre-test and post-test results reveals a consistent increase across all criteria. The largest improvement was observed in students' ability to participate in discussion and explain reasoning, suggesting that the intervention created more opportunities for interaction and expression.

Table 3
Comparison of pre-test and post-test results

Criteria	Pre-test Mean	Post-test Mean	Difference
Presenting ideas	2.85	3.68	+0.83
Explaining reasoning	2.78	3.60	+0.82
Using mathematical language	2.92	3.72	+0.80
Participating in a discussion	2.70	3.65	+0.95
Overall	2.81	3.66	+0.85

The overall mean increased by 0.85 points, indicating a substantial improvement in students' mathematical communication competence.

Discussion

The results show a consistent improvement across all components of mathematical communication competence, and this change did not occur randomly. It reflects the combined influence of the way activities were organized in class, especially the use of learning games together with digital tools.

From the classroom observations and the increase in mean scores, learning games appear to have changed how students participated in lessons. Instead of waiting for teacher prompts, students became more active in responding, explaining, and even questioning each other. The structure of the games required them to articulate answers within a limited time and often justify their choices, which naturally led to more frequent use of mathematical language. This explains why the increase is particularly visible in "participating in discussion" (+0.95) and "explaining reasoning" (+0.82). These findings are consistent with previous studies suggesting that game-based learning creates conditions where communication emerges as part of the task rather than an additional requirement (del Moral Pérez & Guzmán Duque, 2018; Hui & Mahmud, 2023).

The role of digital tools can be seen more clearly in how participation was distributed across the class. With tools such as Kahoot and Quizizz, all students were involved at the same time, not just those who volunteered. The immediate display of results also created moments where students compared answers and discussed differences. In this sense, the tools supported not only engagement but also the transition from individual thinking to shared reasoning. This supports the argument that digital tools can act as mediators of communication by providing multiple ways to represent and exchange ideas (Goos & Sakurai, 2023; Delima & Elfandi, 2022).

The improvement observed in the results can be explained by several interacting factors. One factor is the increased frequency of communication. Students were repeatedly placed in situations where they had to explain, respond, and discuss, which gradually reduced hesitation. Another factor is motivation. The game format made tasks more appealing, so students stayed engaged longer and were more willing to participate. In addition, the classroom environment became less formal, which reduced anxiety and allowed students to express incomplete or developing ideas without fear of being wrong.

When compared with earlier research, the findings follow a similar pattern. Studies have shown that communication in mathematics improves when students are given opportunities to interact and negotiate meaning (Pourdavood & Wachira, 2015). Research on digital game-based learning also reports gains in motivation, confidence, and participation (Hung et al., 2014; Jabbar & Felicia, 2015). The present study confirms these trends but also shows that the combination of games and digital tools may create stronger effects than using either approach alone, particularly in lower secondary classrooms where students are still developing confidence in expressing ideas.

Conclusion

The results of the study indicate that students' mathematical communication competence improved after the implementation of lessons integrating learning games and digital tools. The increase is evident not only in test scores but also in classroom behavior, where students participated more actively, explained their thinking more clearly, and engaged more frequently in discussion.

What stands out is not just the level of improvement, but the way it happened. When students were placed in situations that required interaction, supported by tools that allowed everyone to participate, communication became a natural part of learning rather than a separate objective. This suggests that developing communication competence depends heavily on how learning activities are designed.

The findings provide a practical direction for teaching mathematics in lower secondary education. Integrating game-based activities with digital tools can create a learning environment that encourages students to express ideas, listen to others, and refine their thinking through interaction.

At the same time, the study was limited to one group of 65 students and a relatively short intervention period. Further work could extend the duration, involve more schools, or compare different teaching approaches to better understand long-term effects. Even with these limitations, the findings still offer useful initial evidence that this approach can be applied effectively in the context of Tuyen Quang province.

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