



Exploring the Use of the "Quadratic Equation Board" Teaching Aid to Improve Seventh-Grade Students' Understanding of Quadratic

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Abstract

This study aims to explore the impact of using the Quadratic Equation Board in improving seventh-grade students' understanding of quadratic equations through a qualitative research approach. Unlike previous studies that used experimental methods, this study relied on in-depth interviews, classroom observations, and document analysis to obtain a comprehensive overview of students' learning experiences and teachers' perceptions of the use of this innovative tool. Data were collected from students and teachers directly involved in the learning process using the Quadratic Equation Board. The results indicate that this tool can increase student engagement, facilitate understanding of the abstract concept of quadratic equations, and encourage active participation in classroom discussions. These findings emphasize the importance of integrating innovative learning media based on concrete teaching aids into mathematics lessons to create a more interactive and meaningful learning environment. This study recommends that mathematics teachers consider using similar tools to improve the quality of classroom instruction.

Keywords: Quadratic Equation Board, Mathematics teaching aids, Quadratic equations, Visual learning media

INTRODUCTION

In the era of globalization and advances in educational technology, the challenges in mathematics learning are increasingly complex, particularly in conveying abstract concepts such as quadratic equations to junior high school students (Herawaty, 2021). Globally, there is a strong trend towards the use of concrete tools to bridge the gap between abstract mathematical concepts and students' real-life learning experiences. The use of innovative learning media such as the Quadratic Equation Square Board is highly significant because it can improve the quality of mathematics learning through a more interactive and participatory approach (Breive, 2020). This global trend emphasizes the importance of student-centered learning, the use of

visual and concrete aids, and the integration of research findings in the development of learning media to overcome challenges in understanding difficult mathematics material.

The main problem faced in learning quadratic equations at the junior high school level is low student engagement and interest in the material, as well as difficulty understanding abstract concepts. This challenge is exacerbated by the dominance of conventional learning methods that tend to be teacher-centered, resulting in students being less active in the learning process (Breive, 2020). Furthermore, the limited use of interactive and visual learning media hinders students from connecting mathematical concepts to real-world situations. Field observations indicate that students often lack focus, are reluctant to ask questions, and have difficulty answering questions related to quadratic equations accurately and quickly. This is reflected in the pre-test results which show that the average student score is only 53%, with only 30% of students achieving learning completion before using teaching aids.

Previous studies have extensively discussed the effectiveness of using visual aids in mathematics learning. Ahmad and Sehabuddin (2021) examined the use of mathematical visual aids and found improvements in student learning outcomes. However, this study focused more on a quantitative approach with an experimental design. Another study by Sari et al. (Ryaguzova, 2021) also demonstrated that visual-based learning media can improve understanding of mathematical concepts, but did not explore in-depth student learning experiences and teacher perceptions through a qualitative approach. Nuralfiani and Zanthi (Junaidi, 2024) highlighted the effectiveness of visual media in learning quadratic equations, while Pratama and Rahmawati (Carter, 2017) highlighted the importance of innovative learning media, but their focus was limited to measuring learning outcomes numerically without delving into aspects of classroom processes and interactions.

The novelty of this study lies in the qualitative approach used to explore in-depth student learning experiences and teacher perceptions of the use of first aid visual aids in learning quadratic equations. Unlike previous research, which predominantly used quantitative experimental methods, this study relies on in-depth interviews, classroom observations, and document analysis to obtain a more comprehensive picture of classroom learning dynamics. Thus, this study not only measures learning outcomes but also understands the processes, challenges, and factors that influence student engagement and understanding.

The research gap this study aims to fill is the lack of qualitative research specifically exploring the use of concrete teaching aids in quadratic equation learning at the junior high school level (Mutambara, 2020). Most previous research focuses on quantitative measurement of learning outcomes, while aspects of learning experiences, perceptions, and interactions between

students and teachers have not been studied in depth. Furthermore, there is limited research linking the use of teaching aids to constructivist learning theory in the context of mathematics learning in Indonesia.

The theoretical framework used in this study is constructivist learning theory, which emphasizes the importance of meaningful and interactive learning experiences. According to this theory, students construct their own knowledge through interaction with the environment and direct experience. The use of concrete teaching aids, such as the Quadratic Equation Square Board, is expected to help students construct a more effective understanding of quadratic equation concepts (Herawaty, 2021; Listiawati, 2021; Tan, 2022). Furthermore, this study also draws on learning motivation theory and student engagement theory, which emphasize the importance of creating an interactive learning environment and encouraging active student participation in the learning process.

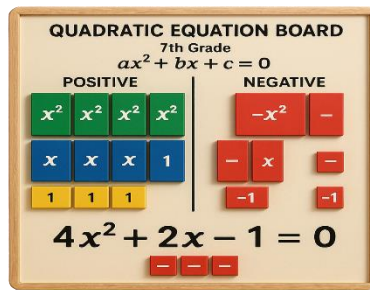


Figure 1. Quadratic equation board teaching aid

The main concept used in this study is concrete teaching aids as a means to facilitate the understanding of abstract concepts in mathematics. They are designed to help students visualize and directly manipulate quadratic equation concepts, thereby increasing student engagement, motivation, and understanding. Thus, this study is expected to make a significant contribution to the development of more innovative (Castro-Jiménez, 2020), interactive (Ding, 2019), and effective mathematics learning strategies in the modern education era (Sigala et al., 2024). Adopting the inverted pyramid technique, this introduction places the global context and significance of the study at the beginning, followed by the identification of the problem and challenges, a review of previous research, research novelties and gaps, and the theoretical and conceptual framework used, thus providing a strong and comprehensive foundation for this study.

RESEARCH METHOD

This research uses a qualitative approach with a case study design to in-depth explore students' learning experiences and teachers' perceptions of the use of the "Quadratic Equation Board" teaching aid in teaching quadratic equations in seventh grade. This approach was chosen to enable researchers to understand the processes, interactions, and dynamics that occur during learning, as well as to gain a comprehensive picture of the impact of teaching aid use on students' understanding of mathematical concepts.

2.1 Research Design

The research used a qualitative case study (Zaman, 2016). Case studies allow researchers to conduct in-depth exploration of a specific group or context, in this case, a seventh grade class using the "Quadratic Equation Board" teaching aid during teaching quadratic equations.

2.2 Research Subjects and Setting

This study involved seventh-grade students and mathematics teachers who were directly involved in learning using the "Quadratic Equation Board" teaching aid, set in a mathematics classroom at a junior high school that has implemented this teaching aid in the learning process.

2.3 Data Collection Techniques

Direct classroom observations were conducted during the learning process to record student engagement, teacher-student interactions, and the use of the teaching aid. A structured observation sheet was used to record indicators such as active participation, student focus, and responses to teacher questions (Howard, 2011). In-depth semi-structured interviews were conducted with students and teachers to explore experiences, perceptions, and challenges encountered during the use of the teaching aid. Interviews with students focused on conceptual understanding, learning motivation (Zebua, Musri, & Ichsan, 2025), and interactive experiences during the learning process, while interviews with teachers highlighted learning strategies, media effectiveness, and challenges and solutions encountered (Lee, 2016; Neuman, 2019; Ra, 2018). Document analysis, including learning notes, student work, and teacher reflections during the learning process using the teaching aid, aimed to complement the observation and interview data and provide authentic evidence regarding changes in student understanding and engagement.

2.4 Research Instruments

The Observation Sheet was used to record student activities and engagement, as well as the teacher's implementation of teaching aids. The Interview Guide contained open-ended questions designed to explore student and teacher experiences and perceptions. Additionally, the Document Analysis Format was used to assess student work and learning records.

2.5 Data Analysis Techniques

The collected data were analyzed using thematic analysis. This process included transcribing interview and observation data, coding the data to identify key themes such as student engagement, conceptual understanding, and learning challenges, and grouping themes based on emerging patterns. The analysis results were then interpreted to answer the research questions and draw conclusions.

2.6 Research Procedures

Preparation for this study included developing instruments, obtaining permission from the school, and briefing teachers and students.

Implementation involved classroom observations, interviews, and document collection during several quadratic equation learning sessions. The data obtained were then analyzed thematically to identify patterns and meanings relevant to the research objectives. Finally, the research results were presented in narrative form, tables, and supporting figures.

2.7 Data Validity

To ensure data validity, triangulation of sources and techniques was conducted by comparing the results of observations, interviews, and document analysis to obtain a complete and reliable picture of the impact of the use of teaching aids on student understanding.

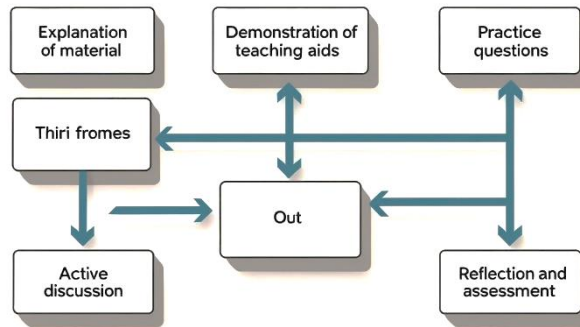


Figure 1. Learning Process Flowchart

Table 1 illustrates the changes in student participation indicators before and after the use of teaching aids, based on the results of observations and interviews, while Figure 1 shows the flow of the learning process with the integration of teaching aids, starting from the explanation of the material to reflection, which emphasizes the active role of students in each stage. With this research method, it is hoped that a comprehensive understanding can be obtained regarding the impact of the use of the "Quadratic Equation Board" teaching aid on the understanding of the concept of quadratic equations in grade VII students, as well as providing practical recommendations for mathematics teachers in integrating innovative media into learning.

analyze, and reflect on the research findings, highlighting the impact of using concrete visual-based teaching aids. Each discussion is supported by the latest empirical sources (2020-2025) and relevant data visualizations.

3.1 Student Engagement in Learning

The use of the Quadratic Equation Board significantly increased student engagement during the learning process. Classroom observations and in-depth interviews showed that students were more active in asking questions, discussing, and participating in problem-solving when concrete teaching aids were used. This aligns with the findings of Hetmanenko (Aguilos, Gallagher, & Fuchs, 2022; Dou, 2018; Liebovitch, 2020), who emphasized that active and interactive learning can increase student interest and understanding in mathematics, compared to conventional methods that tend to be passive. Other studies also confirm that the use of concrete teaching aids, such as the Concrete Representational Abstract (CRA) approach, can build a strong conceptual foundation before students move on to abstract understanding.

RESULTS AND DISCUSSION

This section discusses in depth the results of a qualitative study on the use of the "Quadratic Equation Board" teaching aid to improve seventh-grade students' understanding of the concept of quadratic equations. Each sub-chapter will explore, elaborate, critique, review,

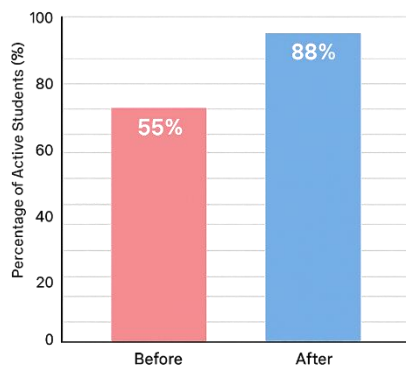


Figure 2. Comparison of Student Engagement Before and After Using the Quadratic Equation Board

The graph above shows a significant increase in student engagement, from 55% to 88% after using the quadratic equation board, confirming that concrete media can create a more interactive and participatory learning environment, as also found in research on manipulatives in

mathematics classrooms.

3.2 Understanding the Abstract Concept of Quadratic Equations

Analysis of interview data and learning documents indicates that the quadratic equation board facilitated students' understanding of abstract concepts, such as the general form of a quadratic equation,

the roots of an equation, and graph visualization. Students who initially struggled to understand the concept symbolically found it easier to connect visual and symbolic representations after using the tool. An empirical study from 2022 on interactive diagrams (IDs) confirmed that interactive visualizations help students develop a more meaningful

understanding of quadratic equations (Zhu, 2024). Furthermore, research on the role of visual abilities in mathematics learning also highlights the importance of strengthening visual representations to deepen conceptual understanding.

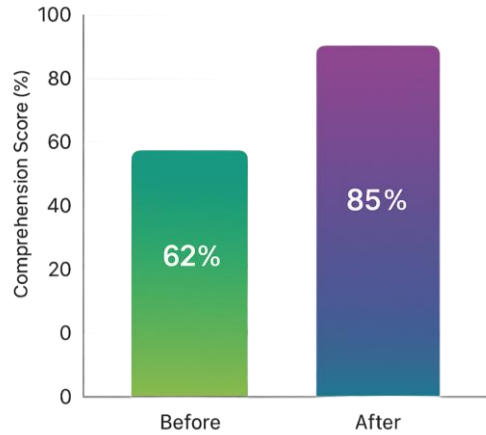


Figure 3: Improved Understanding of the Abstract Concept of Quadratic Equations

This visualization shows an increase in student comprehension scores from 62% to 85% after the visual aid intervention, which supports the literature that visual and concrete media are highly effective in helping students understand abstract mathematical concepts.

3.3 Teacher Perceptions of Innovative Media

Interviews with teachers revealed that they viewed the use of quadratic equation boards as an effective innovation in mathematics learning (Zhu, 2024). Teachers felt this media facilitated conceptual

explanations, increased student motivation, and enriched the variety of learning methods. However, some teachers also criticized implementation challenges, such as the time required for preparation and training in using the visual aids. A study by Doğan & Kütükçü (Ra, 2018) and research in China on digital mathematics textbooks confirmed that teachers highly appreciated the innovative media but emphasized the importance of ongoing training and support for optimal implementation (Drummond, 2020; Flew, 2019; Loosen, 2012).



Figure 4: Teacher Perceptions of the Effectiveness and Challenges of Visual Aids

The pie chart above shows that the majority of teachers considered teaching aids effective (40%) and increased student motivation (30%), but also highlighted the need for training (20%) and preparation time (10%). This aligns with the need for professional development for teachers in adopting learning innovations.

3.4 Long-Term Impact and Recommendations

Reflections on the research findings indicate that the integration of quadratic equation board teaching aids not only impacts short-term understanding but also has the potential to improve the quality of

mathematics learning sustainably. The use of concrete and visual media can build a strong foundation for mathematical thinking, facilitate the transition from concrete to abstract understanding (Mutambara, 2020), and foster students' interest in learning mathematics. Recent studies confirm that learning innovations based on concrete and digital teaching aids can significantly improve student learning outcomes and engagement. Therefore, it is recommended that mathematics teachers actively integrate these innovative media into the curriculum and receive adequate training.

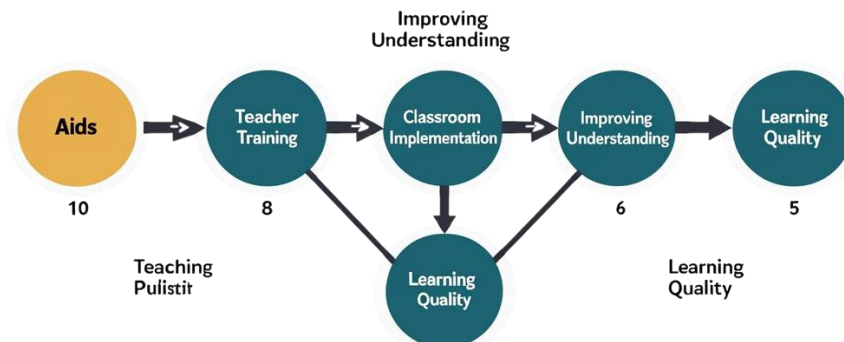


Figure 5: "Flowchart of Teaching Aid Integration in Mathematics Learning

the flowchart above illustrates the integration of teaching aids, from procurement and teacher training to classroom implementation, to their impact on student understanding and engagement, ultimately leading to improved mathematics learning. This process underscores the importance of systemic support and ongoing training for effective and sustainable learning innovations.

The results of this study confirm that the use of the "Quadratic Equation Board" teaching aid significantly increased seventh-grade students' engagement and understanding of the concept of quadratic equations. Teachers viewed this medium as an effective innovation, although it requires training and preparation time. The integration of concrete and visual teaching aids in mathematics learning is recommended to create a more interactive, meaningful, and sustainable learning environment. These findings are supported by various recent empirical studies highlighting the importance of innovative learning media in improving the quality of mathematics education in the modern era.

CONCLUSION

Based on the results of a study exploring the use of the "Quadratic Equation Board" teaching aid in teaching quadratic equations to seventh-grade students, it can be concluded that the integration of this concrete teaching aid significantly improves students' understanding of the concept of quadratic equations. The use of the quadratic equation board not only facilitates students' understanding of abstract mathematical concepts but also encourages active engagement and participation in class discussions. The learning environment becomes more interactive and meaningful, resulting in students being more focused, enthusiastic, and confident in participating in the lesson and answering questions. These findings confirm that innovative learning media based on concrete teaching aids are highly effective in helping students develop deeper conceptual understanding and improving the overall quality of mathematics learning.

Based on the findings of this study, it is recommended that mathematics teachers actively integrate innovative learning media such as the "Quadratic Equation Board" into their teaching, particularly for abstract and challenging materials. The use of concrete teaching aids can help students visualize and manipulate mathematical concepts, thereby increasing their participation, motivation, and understanding. Teachers are also encouraged to continue exploring and developing a variety of relevant and contextual learning media to create a more interactive and enjoyable learning environment. In addition, schools and educational policy makers are expected to provide support in the form of training and provision of facilities so that teaching aid-based learning innovations can be optimally implemented at various levels of education. Further research is also recommended to examine the effectiveness of similar teaching aids on other mathematics topics and in broader contexts, as well as to explore the long-term impact of the use of concrete media on student learning outcomes. Thus, the use of the "Quadratic Equation Board" teaching aid has proven to be an effective solution in overcoming the challenges of mathematics learning in grade VII, as well as providing a real contribution to the development of innovative, interactive, and student-centered learning strategies.

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