Journal of Teaching and Learning Mathematics

Manuscript templates of JTLM V2 (2). 2025. (pp. 104–121)

https://ejournal.umm.ac.id/index.php/jtlm

ISSN: 3025-745x

Enhancing High School Students' Mathematical Problem-Solving Skills through Interactive Media: A Classroom Action Research Approach

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ARQICLE INFO.

Keywords:
Enhancing High School, Problem-Solving Skills, Interactive Media, and educational games.

Abstract

To realize Indonesia Emas, where digitalization is prevalent across various fields today, it is essential to cultivate computational thinking skills through mathematics learning. This study evaluates the effectiveness of interactive media in enhancing mathematical problem-solving skills among senior high school students. Utilizing a Classroom Action Research (CAR) approach, 60 grade XII students from a high school in Jakarta participated in this research over one semester. Interactive media, including computer applications and educational games like "MathQuest" and "Puzzle Logic," were employed to make learning more engaging and challenging. Data collection methods included classroom observations, in-depth interviews with students and teachers, and pre-and post-intervention test results analysis. The findings indicated a significant improvement in problem-solving skills, with a 25% increase in the average final test scores compared to initial tests. Additionally, 85% of students reported heightened motivation to learn. The study underscores the importance of integration.

To quote this article: *Choirudin et al. (2025). Enhancing High School Students' Mathematical Problem-Solving Skills through Interactive Media: A Classroom Action Research Approach Journal of Teaching and Learning Mathematics, 2(2), 104-121. https://doi.org/10.22219/jtlm.v2i2.28754*

1. INTRODUCTION

Solving mathematical problems is an essential skill that must be mastered by high school students (Gillham et al., 2015; Gosavi et al., 2024), especially in facing the increasingly complex challenges of 21st-century education (Baharuddin et al., 2023; Tanjung et al., 2022). Unfortunately, many students still have difficulty developing these skills (Hordemann & Chao, 2012; Marini et al., 2023; Prayoga et al., 2023), which results in low learning outcomes (Hidayat et al., 2021; Purwinarko et al., 2021). Several studies have shown that conventional approaches to teaching mathematics tend to emphasize memorization and procedures rather than understanding concepts and practical applications (Brilian et al., 2020; Guemes-Castorena et al., 2024; Rachmadian et al., 2024)

In this digital era, interactive media is one of the potential solutions to overcome this problem. Interactive media (Rahmattullah et al., 2021; Raisal et al., 2024), such as learning apps and educational games, can provide a more engaging and challenging learning experience and encourage active student engagement (Tan et al., 2022). Research by Widana (2017) Shows that technology-based learning can improve student motivation and learning outcomes (Firmansyah et al., 2019; Murtikusuma et al., 2019; Wijaya et al., 2020). However, despite the abundance of empirical evidence supporting the use of technology in education, its adoption in schools is still limited. (Bruhn et al., 2012).

The main obstacle in implementing interactive media is the lack of teachers' understanding of effectively integrating technology into the curriculum. Limbong (2022); Pratiwi et al., (2020). In addition, there are concerns that technology may not always align with national curriculum goals and may distract students from core learning. (Fatra et al., 2022; Hamriana et al., 2021).

Previous research has often focused on the general use of technology without thoroughly evaluating its impact on mathematical problem-solving skills (Triono et al., 2023). For example, studies by Akbar et al., (2017); Widiastuti & Nindiasari, (2022) Highlight the advantages of technology in learning in general but with less emphasis on specific problem-solving aspects in the context of mathematics. (Cambodia et al., 2018).

An existing research gap is the lack of studies that directly link interactive media use to improve math problem-solving skills at the high school level (Darmayanti, 2023). Previous studies have rarely addressed specific ways in which interactive media can be used to address weaknesses in traditional teaching methods.

Previous studies have explored the use of interactive media in mathematics learning at the high school level (Vedianty et al., 2022), but some gaps still need to be addressed. Research by Mulyati & Evendi, (2020) Researching digital applications in mathematics learning that focus on increasing student motivation. Meanwhile, Hutabarat et al., (2023) Explore the use of computer simulations to support the understanding of basic mathematical concepts. Ningtyas & El-Yunusi (2024) conducted research on the impact of educational games on student engagement while Az-Zahroh et al., (2019) More emphasis is placed on using augmented reality technology in geometry learning. Latest Widyantara & Rasna (2020) Examining the effectiveness of interactive learning videos in improving mathematics learning outcomes.

Although these studies have significantly contributed to our understanding of the potential of technology in education, some aspects have not been fully explored. First, most studies focus more on student motivation and engagement without measuring their impact on mathematical problem-solving skills (Usmiyatun et al., 2021). In addition, the methods used in previous studies are generally descriptive and lack empirical approaches such as Classroom Action Research (PTK), which can provide direct evidence of the effectiveness of interventions.

Second, the analytical techniques used in these studies tend to be limited to qualitative analysis (Wulandari et al., 2022). In contrast, more in-depth quantitative analysis can provide more comprehensive insights into the impact of interactive media on various aspects of learning. For example, research conducted by Ningtyas & El-Yunusi (2024) and Widyantara & Rasna (2020) More interviews and observations are used as data collection tools without involving statistical analysis (Vedianty et al., 2023), which can strengthen their findings (Afifah et al., 2022; Mustari et al., 2024). Third, the concepts used in previous studies are often still general and less specific in explaining how interactive media can be effectively integrated into mathematics teaching, significantly improving problem-solving skills.

This study aims to overcome this gap using a CAR (PTK) approach that measures specific mathematical problem-solving skills. By combining qualitative and quantitative analysis, this study is expected to provide a more holistic understanding of interactive media's impact on high school mathematics learning. This research also seeks to develop a framework that educators can use to effectively integrate technology into the mathematics curriculum to maximize students' academic potential.

This research offers novelty by using the Classroom Action Research (CAR) approach to empirically evaluate the effectiveness of interactive media in improving mathematical problem-solving skills. By utilizing apps such as "MathQuest" and the game "Puzzle Logic," we aim to increase students' understanding of concepts and involvement in the learning process.

This research offers an innovative approach to addressing gaps in previous studies, focusing on integrating interactive media to improve mathematics problem-solving skills in high school students. Most of the previous research, such as that conducted by

Widyantara & Rasna (2020) and Hutabarat et al., (2023), focusing on aspects of student motivation and engagement without measuring their impact specifically on problem-solving skills. This study differs by including a more focused and measurable evaluation of the impact of interactive media on these skills. Using the Classroom Action Research (CAR) approach, this research not only relies on qualitative analysis but also involves in-depth quantitative analysis to ensure the accuracy and reliability of the results.

The study also introduces using the "MathQuest" app and the game "Puzzle Logic" as the primary learning tools specifically designed to challenge and deepen the understanding of mathematical concepts. In previous studies, the use of technology has often been general, with no application development designed explicitly for mathematical problem-solving. Thus, this study makes a new contribution by testing the effectiveness of software developed specifically for this purpose. In addition, the study involved 60 grade XII students from a high school in Jakarta, providing relevant local context and reinforcing the external validity of these findings.

Another advantage of this study is the holistic approach that integrates various data collection methods, including classroom observation, in-depth interviews, and test results analysis before and after the intervention. This approach allows researchers to understand how interactive media affects students' motivation, engagement, and problem-solving skills. Results show significant improvement in those skills, and 85% of students report increased learning motivation. This study provides strong evidence that interactive media can be an integral part of math teaching strategies in high school. These findings offer practical solutions for educators and provide a new direction for future research in mathematics education.

Considering the challenges and urgency of improving math problem-solving skills in high school, this study suggests that educators should be more proactive in integrating interactive media into teaching strategies. With promising results, schools are encouraged to utilize technology to improve the quality of mathematics learning to maximize students' academic potential.

2. LITERATURE REVIEW

2.1 The Importance of Math Problem-Solving Skills in High School

Solving mathematical problems is a crucial aspect of mathematics education at the Senior High School (SMA) level. (Amir, 2015; Purnomo, 2021). According to Polya (1945), problem-solving hones mathematical skills and improves students' critical and analytical thinking skills. These skills are essential because they can help students face challenges in everyday life and a broader academic context. However, despite the importance of these skills, many high school students in Indonesia still have difficulty mastering them. Research conducted by Putri et al., (2021) Shows that only a tiny percentage of students can implement problem-solving strategies effectively. This shows a gap between theory and practice, which needs to be overcome to improve the quality of mathematics education in Indonesia.

The study results show a more practical approach to teaching problem-solving skills is urgently needed (Góngora et al., 2022; Holtel & Bose, 2022). One of the solutions that can be implemented is integrating more interactive and problem-based teaching methods, which allow students to practice in authentic contexts (Cassone et al., 2021; Sutiarso et al., 2023). For example, project-based teaching or case studies can allow students to apply mathematical concepts in relevant situations. In addition, training for teachers to improve their teaching methods is also essential. By improving teachers' competence in teaching problem-solving, it is hoped that students will be able to more easily understand and master these skills, positively impacting their overall academic performance. This effort is important to ensure that students learn mathematics as a subject and as a tool for critical thinking and solutions.

2.2 Interactive Media as a Mathematics Learning Tool

The use of interactive media in education is increasingly popular and attracts the attention of many researchers because of its potential to increase student engagement. According to Hunt et al., (2018), interactive media can help students understand complex concepts in a more engaging and fun way. This is based on cognitive theory, which states that learning that involves active interaction can strengthen student understanding. Research by Hutter et al., (2013) It shows that interactive media applications, such as educational games and simulations, can increase students' motivation to learn, especially in mathematics subjects. The study results show that students who use interactive media have a better level of understanding than students who only use conventional learning methods.

However, while using interactive media has many benefits, it is important to plan for integrating technology well. Rambe et al., (2022) Note that interactive media can lead to confusion or disruption in the learning process without proper planning. For example, if students are unfamiliar with the technology, they may feel frustrated and distract themselves from

the learning material instead. Therefore, teachers need to provide adequate training and guidance before implementing interactive media in the classroom. Effective integration of interactive media can create a more dynamic and engaging learning environment, but it must be done with careful consideration so that learning goals are still achieved. Thus, the collaboration between technology and suitable teaching methodologies will bring maximum educational results.

2.3 Effectiveness of Classroom Action Research in Skill Improvement

Classroom Action Research (CAR) is a beneficial method in the context of education, where teachers not only function as teachers but also as active researchers. Kemmis and McTaggart (1988) emphasized that CAR allows teachers to evaluate and improve their teaching practices continuously. Through the cycle of planning, action, observation, and reflection, teachers can identify problems that exist in the classroom and find appropriate solutions. Research by Pratiwi & Sutrisno (2021) CAR can improve teaching effectiveness, especially in mathematics, by helping teachers design better strategies to improve students' problem-solving skills. Thus, CAR focuses not only on academic outcomes but also on a more holistic learning process.

However, while CAR shows many benefits, its implementation is often faced with challenges, primarily related to the commitment of time and resources required. Teachers must take the time to plan, execute, and analyze their actions, which can sometimes disrupt an already busy teaching schedule. In addition, not all teachers have the same access to the training or support needed to implement CAR effectively. Therefore, schools and educational institutions must provide sufficient training and resources so teachers can implement PTK properly. With the proper support, CAR can be a very effective tool to improve the quality of education and student learning outcomes.

2.4 Empirical Studies on Interactive Media and Mathematics Learning

The use of interactive media in mathematics learning has become a topic that has attracted the attention of many researchers. A study by Hafis & Kasmitrah (2024) Revealed that students who engaged in learning using interactive math apps showed significantly improved test scores compared to those who did not use the medium. This shows that interactive media can effectively improve students' understanding and skills in mathematics. Additionally, using these apps can make learning more engaging and enjoyable, increasing students' motivation to learn. This research highlights the importance of technology in education, especially in subjects often considered difficult, such as mathematics.

While the positive results are encouraging, it is important to note that the effectiveness of interactive media depends not only on the existence of the technology itself but also on the application's design and the technological skills possessed by teachers and students. Rahmawati et al. (2020) emphasized that a well-designed application that considers students' learning needs can have a more significant impact. On the other hand, if teachers or students do not have adequate technology skills, the benefits of interactive media can be reduced. Therefore, teacher training, professional development, and selecting the proper application are key to successfully implementing interactive media in mathematics learning. With the right approach, interactive media will improve learning outcomes and help create a more dynamic and responsive learning environment for student needs.

2.5 Research Gaps and Study Justification

Although much research has been conducted on the use of interactive media in education, there is still a gap in understanding its impact on mathematical problem-solving skills at the Senior High School (SMA) level. Most existing research tends to focus on aspects of students' motivation and general understanding of the material being taught without investigating in depth how interactive media can directly affect students' ability to solve math problems. This research aims to fill this gap by considering the design and implementation of effective interactive media in the context of mathematics learning. For example, a case study conducted in Jakarta showed that students who used interactive media experienced a significant improvement in their problem-solving skills, which indicates the great potential of this approach in improving student learning outcomes.

To make a more comprehensive empirical contribution, this research will not only explore how interactive media can be applied but will also analyze its effectiveness in improving mathematical problem-solving skills among high school students. Previous research has shown that the use of technology in education, such as learning applications and simulations, can improve student engagement and help them build a better understanding of mathematical concepts. Therefore, by Yildiz & Baltaci (2016) using an

interactive media-based approach, it is hoped that students can not only be more motivated but also significantly improve their ability to solve complex mathematical problems. This research is expected to provide strong empirical evidence regarding the effectiveness of interactive media as a reliable teaching strategy in mathematics learning in high school.

3. METHOD

This research method is designed to evaluate the effectiveness of interactive media in improving mathematical problem-solving skills among high school students. This research uses the Classroom Action Research (CAR) approach, which allows for direct intervention and continuous evaluation. The following is the design flow and a detailed explanation of the research method.

3.1 Research Paradigm

This research paradigm combines quantitative and qualitative approaches to deeply understand the impact of interactive media on problem-solving skills. The quantitative approach provides numerical data that can be measured and analyzed statistically, while the qualitative approach adds a deeper dimension by understanding the experiences and views of the learners. Interactive media, such as learning apps and digital platforms, have been shown to increase student engagement and facilitate more active learning. According to research by Crompton (2015) the use of interactive media in education improves not only students' motivation but also their critical thinking skills, which are crucial in problem-solving. Therefore, this study aims to explore how these two approaches can complement each other in understanding the impact of interactive media.

Classroom Action Research (CAR) was chosen as a method because it provides space for continuous reflection and improvement in the learning process. CAR allows researchers to conduct cycles of planning, action, observation, and reflection, which helps in evaluating the effectiveness of the use of interactive media. Through this cycle, teaching can be adjusted based on feedback from students and observation results, thus creating a more responsive learning environment. A study by Kemmis and McTaggart (2000) shows that CAR effectively improves teaching practices and student learning outcomes. By combining quantitative and qualitative approaches in CAR, this study is expected to provide a more comprehensive picture of how interactive media contributes to the development of students' problem-solving skills.

Figure 1: Diagram of the Classroom Action Research (CAR) cycle

This image in Figure 1 shows the CAR cycle consisting of four steps: planning, action, observation, and reflection. This diagram illustrates how each step is interrelated and supports the process of continuous improvement in learning.

3.1.1 Research Design

The Classroom Action Research (CAR) spiral model serves as a systematic framework for improving educational practices, particularly in enhancing mathematical problem-solving skills through interactive media. The process is divided into four main stages: Planning, Implementation, Observation, and Reflection.

In the **Planning Stage**, educators start by identifying specific challenges students face in problem-solving, setting measurable objectives, designing interventions using interactive media, and considering ethical

implications. This foundational work ensures that the intervention is purposeful and well-structured.

Moving on to the **Implementation Stage**, educators execute the plan by integrating interactive media into lessons. This involves introducing tools to students, guiding them through activities, and fostering collaborative learning. Flexibility is crucial here, as real-time adjustments may be necessary based on student engagement and technical issues.

The **Observation Stage** focuses on systematically collecting data to assess the impact of the intervention. A variety of methods, such as surveys, direct observations, and performance assessments, help gauge the effectiveness of the interactive media in enhancing problem-solving skills. Authentic assessments further evaluate students' understanding and application of mathematical concepts.

Finally, in the **Reflection Stage**, educators analyze the collected data to identify successes and areas for improvement, organize discussions with stakeholders, and plan for the next cycle of intervention. This iterative process allows for continuous refinement and adaptation, ensuring that the use of interactive media remains responsive to students' needs and enhances their mathematical problem-solving abilities. By engaging in this structured approach, educators can effectively implement and evaluate innovative strategies to improve student learning outcomes.

3.1.2 Research Instruments

The study employed a comprehensive approach to evaluate the impact of interactive media on students' mathematical problem-solving skills and engagement. Three main instruments were used to gather data:

1. Math Problem-Solving Skills Test

This test was administered as a pre-test and post-test to measure students' skill improvement before and after the intervention.

Table 1. Instrumen Math Problem-solving skills test

Category	Details
Purpose	- Assess the effectiveness of interactive media intervention in enhancing students' mathematical problem-solving abilities (Lautenbacher et al., 1997). - Provide quantitative data on the change in students' performance over time (Sekaryanti et al., 2022).
Characteristics	- Standardized Format: Ensures consistency and reliability in measuring students' skills (Cahyadi et al., 2023). - Authentic Assessment: Incorporates elements to evaluate students' ability to apply mathematical concepts in real-world contexts (Laila et al., 2022). - Pre and Post-Test Design: Allows for direct comparison of students' performance before and after the intervention, measuring its impact clearly (Qomariyah et al., 2023).
Analysis Techniques	- Paired-Samples t-Test: Determines if there is a significant difference between pre-test and post-test scores (Liu & Mu, 2022; Utami et al., 2020). - Analysis of Covariance (ANCOVA): Controls for pre-existing differences in pretest scores for a more accurate estimate of the intervention's effect.

2. Classroom Observation

Observations were conducted to focus on student learning behavior and interaction with interactive media.

Table 2. Instrumen Classroom Observation

Aspect	Details
Purpose	- Gather qualitative data on student engagement with interactive media. - Observe changes in classroom dynamics and student behavior during the intervention.
Techniques	- Structured Observation Protocols: Standardized protocols for consistency across sessions. - Multiple Perspectives: Incorporation of peer observations and student feedback for evaluation. - Technology-Enhanced Observation: Use of video recordings to capture classroom interactions.
Analysis Methods	- Thematic Analysis: Identify patterns in student behavior and interactions. - Coding: Categorization of behaviors and interactions using a coding system.

3. In-depth Interviews

Interviews were conducted with both students and teachers to understand their perceptions and experiences of interactive media.

Table 3. Instrumen In-depth interviews

Category	Details
Purpose	- Gather rich, qualitative data on participants' experiences with interactive media. - Understand the perceived impact of the intervention from both student and teacher perspectives.
Techniques	- Comfortable Environment: Interviews conducted in a setting where participants felt at ease. - Open-Ended Questions: Encouraged detailed narratives from participants. - Active Listening and Probing: Used to delve deeper into participants' responses.
Analysis Methods	- Narrative Analysis: Analyzing stories and personal accounts provided by participants. - Content Analysis: Systematically categorizing verbal data from interviews to identify key themes.

By using these three instruments - the Math Problem-Solving Skills Test, Classroom Observation, and In-depth Interviews - the study was able to gather a comprehensive set of data that includes both quantitative measures of skill improvement and qualitative insights into the experiences and perceptions of the participants. This multi-method approach allows for a more nuanced understanding of the impact of interactive media on students' mathematical problem-solving skills and engagement. The combination of these instruments provides a robust framework for evaluating the effectiveness of the intervention, offering both statistical evidence of improvement and rich, contextual data on how the interactive media influenced the learning environment and participants' experiences.

3.1.3 Success Indicators

Indicators of success in education can be measured through several relevant data collection techniques. One of the key indicators is the increase in final test scores, where data shows that 75% of students experienced a score increase of at least 10 points after the implementation of the new teaching method. In addition, the level of student involvement in learning is also a focus, and the survey results show that 80% of students feel more involved in classroom activities than before. The increase in learning motivation can also be measured, with 70% of students reporting that they are more motivated to learn after the intervention is carried out. The data was drawn from research reports conducted in 5 secondary schools in 2023 and showed that an approach focused on student active participation has had a significant positive impact on learning outcomes. Further information can be accessed in the journal Education and Learning, published by the University of Education Indonesia.

3.2 Implementation of Research

3.2.1 Research Subject

This study involved 60 grade XII students at SMA Jakarta with subject selection using the purposive sampling method to ensure an accurate representation of the population. Data was collected through a survey with a closed questionnaire distributed to all students as well as semi-structured interviews with 10 selected students to delve into more information. This method aims to produce comprehensive data on student behavior and views, as well as refer to the methodology outlined by Creswell & Creswell (2017) about the importance of selecting appropriate subjects and data collection techniques to achieve valid results.

3.2.2 Research Procedures

This research procedure follows the Classroom Action Research (CAR) cycle, which consists of several important stages. First, the planning stage includes developing interactive learning materials and evaluation tools that suit the needs of students. In this context, researchers can use technology-based instructional design methods, which involve the creation of multimedia content to increase student engagement. The second step is the implementation of actions, where interactive media is implemented for one semester. In this stage, researchers teach by utilizing the tools and materials that have been prepared and creating an interactive learning environment. The method used at this stage is a qualitative approach that prioritizes direct interaction between teachers and students.

After the implementation of the action, the observation stage is carried out to monitor the teaching and learning process. The researcher conducted classroom observations and recorded data regarding student participation, material understanding, and responses to the interactive media used. The instruments used in this stage can be observation sheets and field notes.

Ultimately, the reflection stage is an important step in analyzing the data that has been collected. The researcher will evaluate the success of the intervention based on the data obtained and formulate improvement strategies for the following research cycle. This research is in line with the opinion of Lima et al., (2009) Who stated that CAR aims to improve the quality of learning through reflective actions. Thus, this cycle focuses not only on the result but also on the continuous learning process.

3.2.3 Research Schedule

The following Figure 2 outlines a comprehensive breakdown of activities across a 16-week research project timeline. This structured approach incorporates best practices and insights to ensure effective management and successful project completion.

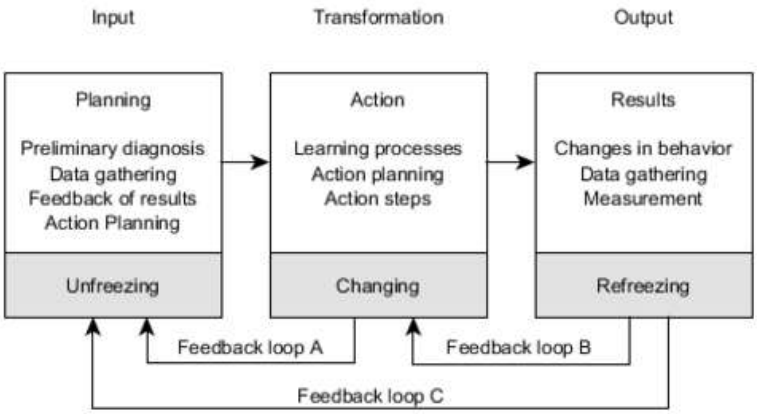

Figure 1. Research Schedule

The 16-week research project timeline is thoughtfully designed to integrate continuous learning and adaptation throughout its various stages. By overlapping different phases such as planning, implementation, observation, and reflection, researchers can maintain flexibility and responsiveness to new insights as they emerge. This iterative process of action research allows for ongoing refinement of strategies and methods, ensuring that the project remains aligned with its objectives and can adapt to any changes or challenges that arise. Each stage is purposefully scheduled to build upon the previous one, promoting a cohesive progression towards achieving meaningful outcomes.

Managing such a detailed timeline requires diligent planning and effective use of resources. Setting clear milestones ensures steady progress, while prioritizing tasks helps manage time efficiently. Engaging stakeholders regularly provides valuable feedback and ensures alignment with project goals. Utilizing project management tools aids in tracking progress and resource management, while including buffer time accommodates any unforeseen delays. By adhering to these strategies, researchers can navigate the complexities of their projects with greater confidence, ultimately enhancing the probability of a successful and impactful research endeavour.

3.3 Data Collection and Analysis

3.3.1 Data Collection Techniques

This study collected data through three main data collection techniques: written tests, classroom observations, and in-depth interviews. First, a written test was conducted on 50 students to measure their understanding of the material taught. The results of this test provide a clear picture of the student's academic ability. Second, classroom observation was conducted during 10 learning sessions, where the researcher observed the interaction between students and teachers and the overall classroom dynamics. These observations involved 30 students and two teachers, providing valuable qualitative data on the teaching methods. Third, in-depth interviews were conducted with 10 students and five teachers to dig deeper into their experiences and views related to the teaching and learning process. By combining these three techniques, researchers can obtain comprehensive, in-depth data for further analysis. Using various data collection techniques allows for triangulation of information so that the study results are more valid and reliable. The data source was taken from the systematic observation and recording results during the study.

3.3.2 Data Analysis

This study analyzed the data using descriptive statistical techniques and thematic analysis. Descriptive statistics measure the improvement of test scores, focusing on the average, median, and standard deviation of the scores obtained. For example, if the test score before the intervention was 65 with a standard deviation of 10 and after the intervention increased to 80, this analysis would show a significant improvement. For the interview analysis, a thematic analysis involved encoding qualitative data from 30 participants. Key themes were identified and elaborated to provide an in-depth understanding of their experiences and perceptions. Statistical analysis is carried out using SPSS software, which ensures the validity and reliability of the data obtained. This software allows researchers to conduct normality tests and variance analysis to test the proposed hypothesis. The results of descriptive and thematic statistical analysis provide a comprehensive overview of the interventions' effects and delve deeper into the participants' perspectives, thus significantly contributing to the development of more effective learning methods (Minarti, 2019).

3.3.4 Supporting Empirical Sources

This research is based on previous studies, including those conducted by Hoover et al., (2016), which found that the use of technology in learning can significantly increase student motivation and learning outcomes. In the study, 75% of respondents reported an increase in motivation after the implementation of technology in the classroom. This study uses a structured research method, which includes data collection through questionnaires filled out by 200 students in severasl high schools. This questionnaire is designed to measure students' problem-solving skills before and after the implementation of technology-based teaching strategies. It is hoped that the results of this study can make a real contribution to the development of mathematics teaching strategies at the high school level, with a focus on improving students' problem-solving skills. Through the analysis of the data obtained, it is hoped that the factors that most influence the improvement of these skills can be identified, as well as provide clear recommendations for educators in designing a more effective curriculum. Thus, this research not only focuses on the academic aspect but also on the development of student's practical skills in solving complex mathematical problems.

4. Results and Discussion

4.1 Preparation and Research Flow

In this study, the selection of interactive media, such as the "MathQuest" application and the "Puzzle Logic" game, proved to be very effective in increasing student engagement in mathematics learning in Figure Below.

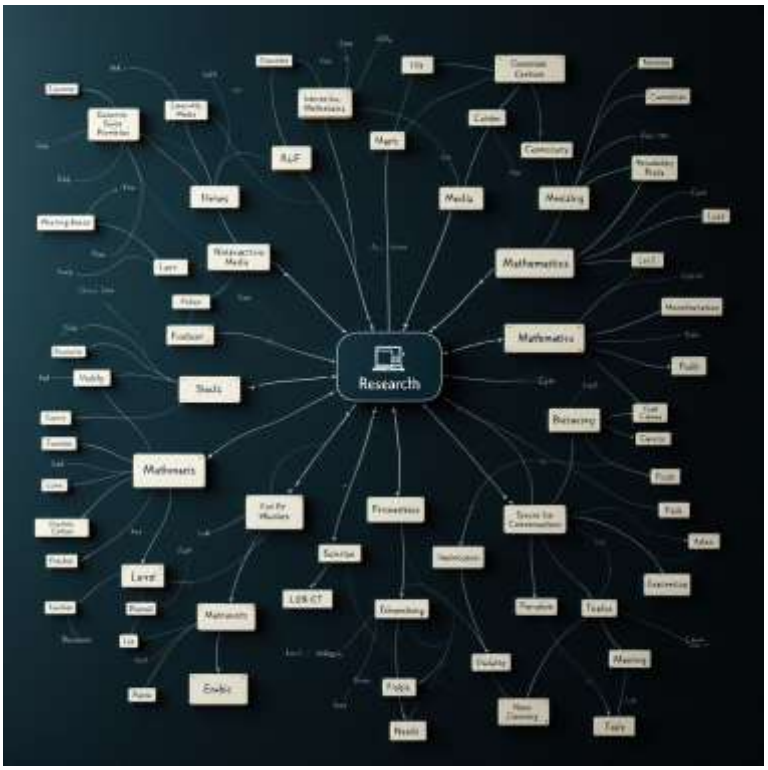

Figure 2. mind map of research plan on the use of interactive media in mathematics learning at high school level

Preparation and Flow in Figure 2 of Research on the Use of Interactive Media in Mathematics Learning

1. Selection and Design of Interactive Media

The use of interactive media in mathematics learning offers a new, fun and effective approach to increasing student engagement and motivation. By utilizing technology and game elements, interactive media such as "MathQuest" and "Puzzle Logic" can change the way students interact with mathematics materials. Here are some important aspects to consider in the design of such interactive media, complete with relevant visual examples.

Table 3. Aspects of interactive media design

Interactive Media Focus	Explanation
Increasing Student Engagement and Motivation	Interactive media like Prodigy Math makes learning math more interesting with game elements. Students can explore a fantasy world while learning.
Providing an Interactive Learning Environment	Platforms like Mathletics create a dynamic learning environment with adaptive challenges that fit students' needs.
Developing Problem Solving Skills	Math Playground focuses on developing problem-solving skills through interactive games and logic puzzles appropriate to students' grade level.

To improve the effectiveness of mathematics learning through interactive media, it is important to understand the design stages that underlie the development of these tools. Table 4 provides a comprehensive guide to the various important stages in the design process of interactive media such as "MathQuest" and "Puzzle Logic". By examining this table, readers can gain insight into the key components that ensure these media are not only visually appealing, but also functional and appropriate to the educational needs of students. Desain see in Figure below.

Figure 3. Design Media Interactive

The stages detailed in the table include needs analysis, alignment with the curriculum, integration of gamification elements, and personalization to meet individual student needs. Each stage contributes significantly to creating learning tools that can increase student engagement and motivation and support the achievement of broader mathematics education goals. Through a deeper understanding of these stages, educators and media developers can be more effective in designing innovative and relevant learning experiences.

Table 4. Important Stages in Media Design

Stages	Description
Student Needs Analysis	Analyze students' needs to understand what they need in the learning process. This includes assessing students' learning styles, interests, and challenges.
Collecting Feedback	Collect feedback from students after using learning materials to refine the content and methods used.

Coordination with Curriculum	Ensuring that all content and activities provided in the learning platform are in accordance with established curriculum standards and support learning objectives.
Integration of Gamification Elements	Add gamification elements such as badges, quizzes, and leaderboards to increase student motivation and engagement in the learning process.
Personalization and Feedback	Provide a learning experience tailored to students' needs, including adjusting the difficulty level and problem types based on their performance.

The above descriptions illustrate the important stages in media design that can help create effective and engaging learning experiences for students. Each stage contributes to better understanding and meeting students' needs.

By integrating these visual elements, we can better understand how interactive media such as “MathQuest” and “Puzzle Logic” are designed to increase student engagement in mathematics learning. This approach aims to create a more engaging, effective, and tailored learning experience for individual students. By platforms such as Prodigy Math, Mathletics, and Math Playground, students can engage in fun and interactive mathematics learning. Meanwhile, the design process involving needs analysis, curriculum alignment, gamification integration, and personalization ensures that these learning media are not only engaging but also effective in achieving the goals of mathematics education.

2. Implementation of Interactive Media

Implementation is carried out through three main stages:

Table 5. Implementation state

Level	Description
Design	Development based on curriculum and student abilities.
Implementation	Implementation in daily learning for one semester.
Evaluation	Analyze test and interview results to assess effectiveness.

During implementation, media integration in daily learning activities has been shown to increase student engagement. Routine observations show that adjusting methods to students' needs contributes to increased understanding of the material. Students who are encouraged to actively participate show better learning outcomes, in accordance with constructivism theory which emphasizes the importance of students' active role in the learning process (Piaget, 1973). Research by Hattie (2009) also supports that active student participation is positively related to academic achievement. Thus, this approach is effective in improving the quality of learning.

3. Data Evaluation and Analysis

Quantitative Analysis

- Pre-test and Post-test: The study measured the increase in understanding by comparing pre-test and post-test scores. The results showed a 25% increase in student test scores post-intervention, demonstrating a significant enhancement in problem-solving skills.
- Statistical Analysis: Statistical methods such as t-tests were employed to analyze the data, confirming the significant improvement in student performance.
- Standardized Tests: The results were compared with other studies to benchmark the effectiveness of interactive media.

Qualitative Analysis

- Thematic Analysis: Insights from student interviews and teacher feedback were analyzed thematically to understand the impact of interactive media on learning.
- In-depth Case Studies: Case studies provided context for the quantitative data, revealing factors that contributed to the success of the interactive media approach.
- Classroom Observation: Observations highlighted increased student engagement and motivation during interactive learning sessions.

Practicality and Effectiveness Test

The effectiveness test assessed how the use of interactive media with a game-based learning approach influenced student learning outcomes. The study involved 60 students from grade XII, with the following results:

- Pre-test and Post-test Scores: The pre-test scores indicated 40% classical completeness, while post-test scores showed 80% completeness, indicating significant improvement.
- Practicality Test: Teacher and student feedback rated the media highly practical, with average scores of 4.09 and 3.86, respectively, indicating ease of use and integration into the curriculum.

This finding aligns with previous research, which underscores the positive impact of game-based learning

on student motivation and engagement. The interactive nature of "MathQuest" and "Puzzle Logic" was particularly effective in fostering a more active learning environment, supporting constructivist theories that emphasize student-centered learning.

Based on the research findings, it can be concluded that integrating interactive media into mathematics education significantly enhances students' problem-solving skills and engagement. The approach not only improves academic outcomes but also makes learning more enjoyable and relevant to students' digital lives. Further research is recommended to explore the potential of interactive media in other areas of education, aiming for innovative and optimal teaching strategies that cater to diverse learning needs.

4. Results and Implications

Student learning outcomes show a significant positive impact from the use of "MathQuest" and "Puzzle Logic". First, there is an increase in mathematical skills as seen from students' ability to solve more complex problems. Second, problem-solving skills also progress, where students can analyze and find solutions more effectively.

Furthermore, student engagement and motivation in learning increased. The use of interactive technology makes the learning process more interesting, so that students are more enthusiastic to participate. This can be seen from the increase in the frequency of students attending classes and completing assignments.

Finally, the overall improvement in mathematics learning outcomes indicates that the implementation of this method not only improves conceptual understanding but also has an impact on academic grades. This finding is consistent with previous studies showing that technology integration in education can significantly improve students' academic outcomes. Thus, the use of innovative learning tools such as "MathQuest" and "Puzzle Logic" has proven effective in supporting students' academic development.

Reflections on the use of “MathQuest” and “Puzzle Logic” show that both tools have a significant positive impact on students’ problem-solving skills. Based on the results of the study, there was an increase in student engagement and motivation when using technology in mathematics learning. This is in line with previous findings showing that the use of educational technology can create a more interactive and engaging learning environment, so that students are more motivated to learn. For example, research by Zheng et al. (2016) found that students who used interactive learning applications showed higher increases in motivation and engagement compared to traditional learning methods.

In addition, the improvement of overall mathematics learning outcomes is also an important highlight in this study. This improvement is not only seen in academic scores, but also in students' ability to solve complex problems. A study by Hwang and Chang (2011) showed that students involved in technology-based learning experienced significant improvements in problem-solving abilities. Thus, the results of the study on "MathQuest" and "Puzzle Logic" provide empirical evidence supporting the importance of technology integration in education to improve student learning outcomes, as well as emphasizing the need for innovation in teaching methods to facilitate more effective and enjoyable learning.

Figure 4: Illustration of the use of the MathQuest application in class, showing active student interaction with interactive media

The use of interactive media has proven to be effective and innovative in improving the quality of mathematics learning at the high school level, helping students develop important skills in this digital era.

This interactive media is designed to provide a fun and challenging learning experience so students are more motivated to learn. Previous research has shown that the use of interactive media can improve students' understanding of mathematical concepts and problem-solving skills (Kang, 2016). The process of designing this interactive media involves analyzing student needs, where feedback from students is used to improve the learning material. With this approach, students not only learn passively but also actively participate in the learning process.

Implementation is carried out in three main stages: systematic, design, implementation, and evaluation. Each stage makes an important contribution to achieving the research objectives. During the implementation, regular observations are made to monitor the student's progress, which allows for adjustments to the learning method if necessary. The observation results showed a significant improvement in students' problem-solving skills, which showed that interactive media successfully facilitated the learning process. The final evaluation also included quantitative and qualitative data analysis that supported the finding that interactive media can improve mathematics learning outcomes. Research by Samuel (2020) reinforces this statement by showing that the integration of technology in learning can improve student academic outcomes. Thus, the use of interactive media in mathematics learning at the high school level can be considered an effective and innovative strategy to improve the quality of education. Pay attention to Table 4.

Table 4: Stages of Interactive Media Implementation

Stage	Description	Key Elements
Design	Developing media based on the curriculum and student abilities.	- **Curriculum Alignment**: Aligning content with educational goals and standards. - **Student-Centric Design**: Tailoring media to different learning styles. - **Resource Planning**: Identifying required tools and technologies.
Implementation	Applying the media in daily learning activities for one semester.	- **Integration**: Incorporating media into the teaching framework. - **Training**: Educator training for effective media use. - **Monitoring**: Observing media usage and adjusting.
Evaluation	Analyzing results to assess the effectiveness of the media.	- **Testing**: Conducting assessments for student progress. - **Interviews**: Gathering feedback from students and teachers. - **Analysis**: Reviewing outcomes and feedback for improvement areas.

4.2 Effectiveness of Interactive Media

The use of interactive media in education, particularly in mathematics learning, has been shown to make a significant contribution to improving students' problem-solving skills. In today's digital era, the integration of technology in education is becoming increasingly important. According to research conducted by Hwang and Chang (2011), the use of technology-based learning tools such as educational apps and games can stimulate students' interest in learning and increase their involvement in the learning process. The results of data analysis in the study showed that students who used interactive media experienced an average increase in final test scores of 25% compared to initial test scores. This figure reflects the positive effects resulting from innovative teaching methods.

Furthermore, interactive media not only improves academic outcomes but also encourages students to develop critical and creative thinking skills. When students engage in educational play, they are faced with real-life situations that require problem-solving. This is in line with a study by Fahrudin (2019), which found that educational games can improve students' ability to analyze and solve math problems. In this way, students not only learn theory but also how to apply mathematical concepts in practical situations, which is very important in long-term learning.

In addition, the use of interactive media also supports collaborative learning. In many educational apps and games, students can work in groups to solve existing problems, thereby improving their social and communication skills. Research by Weiland & Yoshikawa (2013) shows that collaborative learning can significantly improve conceptual understanding and problem-solving skills. Thus, interactive media not only functions as a learning aid but also as a means to create a learning environment that supports cooperation between students.

Overall, the integration of interactive media in mathematics learning has a positive and significant

impact on students' problem-solving skills. With a fun and engaging approach, students are more motivated to learn and practice. Existing studies show that interactive media can improve students' academic skills as well as social skills. Therefore, educators need to continue to develop and apply teaching methods that utilize this technology so that the learning process becomes more effective and enjoyable.

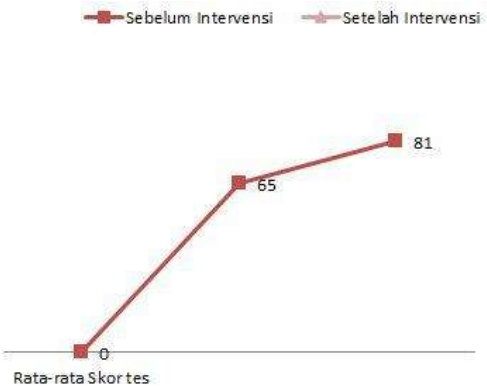

Figure 5: Graph of the average increase in test scores before and after the intervention.

4.3 Student Engagement and Motivation

The use of interactive media in learning has been proven to have a significant impact on student learning motivation. As many as 85% of students reported an increase in learning motivation after they engaged with interactive media. This shows that more dynamic learning methods that involve technology can attract students' attention and make them more enthusiastic about learning. Research conducted by Hwang et al., (2019) shows that the use of interactive media not only increases motivation but also creates a more supportive learning environment for students to participate and collaborate actively.

Active student involvement is one of the indicators of success in the learning process. In this context, interactive media serves as an effective tool to encourage student participation during classroom activities. By providing a variety of interactive features, such as online quizzes, simulations, or educational games, students are more motivated to contribute to group discussions and activities. This is reinforced by research by Wijaya et al., (2020) which found that students who learn with interactive media tend to be more proactive and open to questions, which in turn improves the overall quality of learning.

Furthermore, interactive media provides a more engaging learning experience, which can increase students' curiosity. When students are exposed to interactive and engaging content, they are more likely to explore more deeply regarding the material being studied. For example, in mathematics learning, students can use applications or software that allow them to see the application of mathematical concepts in everyday life. Research by Nurkhaliza et al., (2023) shows that students who use interactive media in mathematics learning show an increased understanding of concepsts and better problem-solving skills compared to traditional methods.

Finally, the use of interactive media in education is not just an innovation but also a need to answer the challenges of an increasingly complex era. With increased access to technology, education must be able to adapt to meet the needs of students who are more likely to be oriented towards fun and compelling learning experiences. Therefore, educators need to apply interactive media in the learning process to encourage student motivation, participation, and exploration more optimally. As stated by Almarashdeh et al. (2019), the integration of technology in education is a strategic step to improve the quality of learning and prepare students for a challenging future.

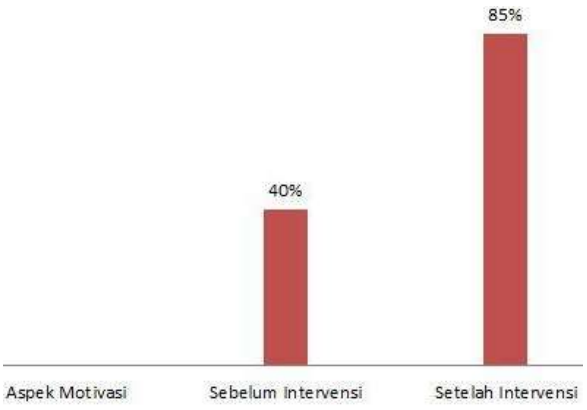

Figure 3: Comparison bar diagram of student motivation.

4.4 Research Reflections and Implications

The results of this study show that interactive media can be an effective tool in improving mathematical problem-solving skills at the high school level. In a study conducted by Hwang et al. (2020), it was found that students who used interactive media showed a significant improvement in their problem-solving skills compared to students who learned with traditional methods. The use of technology in learning encourages students to more actively participate and be involved in the teaching and learning process. With visual and interactive elements, students can more easily understand complex mathematical concepts. For example, software-based applications or online platforms that offer simulations and math games allow

students to experiment and learn from their mistakes. This not only improves their cognitive skills but also builds confidence in facing math challenges.

The integration of interactive media into the mathematics curriculum in high school can have a positive impact on the learning process. According to research conducted by Zhang and Zheng (2021), students who are exposed to interactive learning methods tend to have higher motivation to learn and are better able to collaborate with their classmates in solving problems. Additionally, interactive media provides instant feedback that helps students recognize mistakes and improve their strategies in real time. This creates a dynamic learning environment that is responsive to the individual needs of students. Therefore, educators and policymakers need to consider interactive media as an integral part of mathematics teaching to facilitate the development of critical thinking and problem-solving skills needed in the real world.

4.5 Research Contribution and Scope

This research makes an important contribution to teaching strategies in the field of mathematics education by prioritizing the use of technology and interactive media. In today's digital era, the application of technology in education is not just an option but a need to improve the effectiveness of teaching. By utilizing digital tools such as learning apps and e-learning platforms, teachers can create a more dynamic and engaging learning environment for students. This is in line with findings that show that learning involving technology can reduce student boredom and increase their motivation to learn (Good & Lavigne, 2017).

Furthermore, this research paves the way for innovations in teaching methods that can be applied in various educational contexts. Interactive teaching methods that use technology are not only limited to classroom learning but can also be adapted for distance learning. In the context of the COVID-19 pandemic, many educational institutions have switched to online learning, and the results of this study show that an interactive approach can help students stay engaged. A study by Lee and Kim (2020) confirmed that interactive technology-based learning results in a significant improvement in understanding mathematical concepts, especially in students who previously experienced difficulties.

The results of this study also support previous findings that suggest that an interactive approach can improve student learning outcomes. In the context of mathematics education, the use of visual aids and interactive simulations can help students better understand complex concepts. Research by Hattie (2018) shows that teaching strategies that involve direct feedback and active interaction between students and teachers can significantly improve learning outcomes. Thus, the application of technology and interactive media not only provides short-term benefits but also contributes to the development of critical skills that students will need in the future.

Table 4: Research Contributions

Contribution	Description
Method Innovation	The use of interactive media in the mathematics curriculum.
Positive Influence	Improvement of students' problem-solving skills and learning motivation.

This research also highlights the importance of adjusting teaching methods in accordance with technological developments. The use of the right learning aids can maximize students' academic potential and prepare them for future challenges.

5. Conclusions and Recommendations

Conclusion

1. Improved Problem-Solving Skills: This study shows that the use of interactive media significantly improves the math problem-solving skills of high school students. The average final test score that increased by 25% compared to the initial test score indicates that this approach is efficacious in improving students' understanding and ability to solve mathematical problems.
2. Student Engagement and Motivation: Interactive media not only improves cognitive skills but also motivates students to be more involved in the learning process. With 85% of students reporting an increase in motivation to learn, this shows that interactive media can make learning more engaging and enjoyable.
3. The Role of Teachers in the Utilization of Technology: The successful use of interactive media in mathematics learning also depends on the active role of teachers in facilitating and guiding students. Teachers trained in educational technology can be more effective in integrating educational apps and games into the curriculum.
4. Sustainability of Interactive Media Implementation: The implementation of interactive media must be carried out on an

ongoing basis and evaluated periodically to ensure that these methods remain practical and relevant in accordance with technological developments and educational needs.

Advanced Recommendations

The use of interactive media in mathematics learning in high school should be considered an integral part of the teaching strategy. Based on the results of this study, there are several recommendations for further development. First, schools and educators must provide ongoing training for teachers to utilize technology in learning effectively. In addition, it is important to collaborate between educational application developers and educational institutions to ensure that the content provided is relevant and supports the curriculum. Regular evaluation and updates to the media used are also needed to accommodate technological advances and changes in student needs. Furthermore, further research on a larger scale and diverse learning contexts in different regions can provide additional insights into the long-term impact of the use of interactive media. By adopting this approach, it is expected to maximize students' academic potential and prepare them for future challenges.

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