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The Influence of the Use of Digital Technology on Improving Understanding of Mathematical Concepts in Secondary School Students

Sabrun

Mathematics Education Study Program, FSTT, Undikma Mataram
Corresponding Author Email: sabrun@undikma.ac.id

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Abstract

This study aims to examine the effect of using digital technology on improving the understanding of mathematical concepts in secondary school students. The research was conducted at SMAN 1 Terara by involving 30 students of class X and XI as respondents. The method used was a quasi-experiment with a pre-test and post-test design to measure changes in students' understanding before and after the application of digital technology in mathematics learning. The digital technology used in this study includes interactive math applications and learning videos integrated in the learning process. The results showed a significant increase in the mean scores of the pre-test and post-test, with the pre-test score of 65.4 and the post-test score increasing to 82.1. A paired t-test showed that this difference was statistically significant ($p < 0.05$). This finding indicates that digital technology can significantly improve students' understanding of mathematical concepts. Technology-based learning assists students in understanding difficult mathematical concepts through visualization, interactivity, and self-directed learning. However, the successful implementation of technology is also influenced by teacher readiness and adequate access to technological devices. The conclusion of this study is that the use of digital technology has the potential to improve the quality of mathematics learning in secondary schools. Therefore, it is recommended to further integrate technology in the mathematics curriculum and provide training to teachers to maximize its utilization in learning.

Keywords: *Digital Technology; Concept Understanding Mathematics*

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INTRODUCTION

In today's digital era, technology has permeated nearly every aspect of life, including education. One of the most significant changes is the integration of technology into learning, which not only enhances information accessibility but also transforms the way students engage with learning materials. Mathematics education is one of the disciplines that has felt the profound impact of technological advancement. As a subject that requires deep conceptual understanding, mathematics stands to gain substantial benefits from the use of digital technology in its instructional processes (Zhao, 2022: 15).

Along with technological advancement, a variety of educational applications, software, and digital learning tools have been developed to facilitate the understanding of complex mathematical concepts. Digital technology in mathematics education includes the use of visual media, interactive math software, tutorial videos, and simulations that allow students to explore in-depth concepts that were previously difficult to grasp through conventional methods (Kim & Park, 2023: 45; Lee & Kim, 2021: 30). The use of these digital tools offers students the opportunity to learn independently and interactively, as well as to review material based on their individual needs and capabilities (Wang & Zhang, 2020: 42).

Several studies have shown that technology can improve the quality of mathematics learning in more engaging and enjoyable ways. This helps reduce math anxiety, a subject often perceived as difficult and tedious (Anderson & Brooks, 2021: 50). Students who engage with technology tend to be more motivated and active in the learning process because they can directly interact with learning materials, explore new concepts through simulations, and observe real-life applications (Fletcher & Lee, 2020: 67). Research by Clark and Johnson (2021: 18) also found that technology-based mathematics learning can enhance students' understanding of abstract mathematical concepts, such as geometry and algebra, which often pose challenges for secondary school students.

Despite the many benefits that digital technology offers in mathematics education, challenges remain. One of the primary issues is teacher readiness to integrate technology into the teaching process. Some educators may still feel unskilled or lack confidence in using technological tools in their teaching practices (Newman & Harris, 2019: 82). Additionally, unequal access to digital devices among students can hinder the implementation of technology-based learning, especially in underdeveloped areas (Miller & Sanchez, 2021: 15).

In Indonesia, including at SMAN 1 Terara, the use of digital technology in mathematics instruction has been introduced, but its effectiveness still requires further evaluation. This study aims to examine the impact of digital technology use on students' understanding of mathematical concepts at the secondary school level. The research focuses on grade X and XI students who have begun using math applications and software in their learning. With 30 participating respondents, this study is expected to provide insights into the effects of digital technology on mathematics learning outcomes at SMAN 1 Terara and to offer recommendations for effective mathematics teaching practices in secondary schools.

Previous studies have highlighted the positive effects of digital technology in improving students' understanding of mathematical concepts. For instance, Davis (2019: 30) reported that students who used interactive learning applications experienced significant improvements in their understanding of mathematical concepts compared to those who engaged in conventional learning. Additionally, technology enables more flexible teaching, allowing students to access learning materials anytime and anywhere, thereby increasing learning flexibility (Bell & Morgan, 2020: 58). Moreover, the use of technology in mathematics learning allows students to better comprehend the material through more visual and concrete approaches, which are easier to grasp for most learners (Roberts & Evans, 2022: 12).

However, despite these promising findings, the specific impact of digital technology on students' conceptual understanding of mathematics at the secondary

school level still requires further investigation, particularly within the context of Indonesian education. Therefore, this study aims to fill that gap by evaluating the effectiveness of digital technology in mathematics learning at SMAN 1 Terara and analyzing how such technology can support the improvement of students' mathematical understanding.

This research was conducted from November to January 2025, with the hope of contributing to the development of a more effective mathematics learning model through digital technology integration. Furthermore, it seeks to provide recommendations for teachers and educational policymakers in Indonesia regarding the importance of implementing technology in mathematics education.

METHOD

Research Design

This study adopts a quasi-experimental design using a pre-test and post-test approach to assess changes in students' understanding before and after the implementation of digital technology in mathematics learning. This design was selected because it provides a clearer picture of the effectiveness of digital technology in enhancing students' conceptual understanding of mathematics. In this study, a pre-test was administered before the use of digital technology began, while a post-test was administered afterward to compare students' learning outcomes.

Population and Sample

The population in this study consisted of all Grade X and XI students taking mathematics at SMAN 1 Terara. The sample comprised 30 students randomly selected from these two classes. Random sampling was employed to ensure that each student had an equal chance of participating in the study, thereby making the findings more representative and generalizable.

Research Instruments

Two main instruments were used in this study: a mathematical concept comprehension test and a questionnaire. The comprehension test was designed to measure students' understanding of the taught material and consisted of 20 questions in both multiple-choice and open-ended formats. The test covered a variety of basic mathematical topics, including algebra, geometry, and trigonometry, which were taught during the study period.

In addition to the test, a questionnaire was used to collect supplementary information regarding students' perceptions of using technology in learning. The questionnaire included several items related to students' experiences while using technology during the learning process, whether they felt the technology helped them understand mathematical concepts, and how frequently they used technology in their study activities.

Research Procedure

This study followed several key steps to collect the necessary data:

1. **Pre-test**: Students were given a mathematics comprehension test before the intervention to measure their initial understanding of the subject matter.
2. **Intervention**: After the pre-test, learning activities were conducted using digital technology, such as interactive math applications and instructional videos, aimed at enhancing students' conceptual understanding.

3. **Post-test**: After several learning sessions using digital tools, students were administered the same test as the pre-test to evaluate any changes in their understanding.
4. **Questionnaire**: Upon completion of the tests, students were asked to complete a questionnaire assessing their perceptions of technology-based learning. This was intended to determine the extent to which students felt assisted by technology in understanding mathematical concepts.

Data Analysis

The data collected from the pre-test and post-test were analyzed using a paired t-test to determine whether there was a significant difference between the pre-test and post-test scores. The paired t-test was chosen because it is suitable for comparing two sets of data taken from the same sample group (before and after the intervention). If the analysis reveals a significant difference between the two tests, it can be concluded that the use of digital technology has a positive impact on improving students' conceptual understanding of mathematics.

RESULTS AND DISCUSSION

This study aims to measure the effect of digital technology use on improving students' understanding of mathematical concepts at SMAN 1 Terara. Based on data obtained from the pre-test and post-test, there was a significant increase in students' understanding of mathematical concepts after using digital technology in learning. Data analysis showed that the average pre-test score was 65.4, while the average post-test score increased to 82.1. The difference between these two scores indicates a significant change in students' understanding of the material taught after the implementation of digital technology.

Table. Average student scores on the pre-test and post-test.

Test Type	Mean Score	Standard Deviation
Pre-test	65,4	8,2
Post-test	82,1	7,5

The table above shows that the average student score on the pre-test was 65.4 with a standard deviation of 8.2, indicating significant variation among students. After implementing digital technology in learning, the average post-test score increased to 82.1 with a standard deviation of 7.5. This indicates that, despite the variation, overall student understanding significantly improved after the intervention.

To further understand the significance of this improvement, a paired t-test was conducted. The paired t-test showed a p-value <0.05, indicating that the difference between pre-test and post-test scores was statistically significant. Therefore, it can be concluded that the use of digital technology in mathematics learning has a positive effect on improving student understanding.

Discussion

Based on the results of the study, it is evident that the use of digital technology in mathematics learning has a positive impact on students' understanding of mathematical concepts. The significant increase in post-test scores indicates that

digital tools, such as interactive applications and instructional videos, help students better comprehend mathematical concepts. Several factors may explain these findings:

Visualization and Interactivity

One of the key advantages of using technology in mathematics education is its ability to provide visual representations of concepts that are difficult to grasp through conventional methods. For example, in topics such as geometry and algebra, students can better understand geometric shapes and relationships between elements through interactive simulations that traditional teaching methods cannot offer. According to Lee and Kim (2021: 30), visual media and interactive applications help students "see" mathematics in a more concrete and tangible form, thereby enhancing comprehension.

Independent Learning

Digital technology also allows students to learn independently. Applications and learning videos enable them to study at their own pace, revisit material they have not yet mastered, and access additional resources when necessary. This is particularly important in mathematics, where each student may have a different learning speed. Previous research has also shown that technology-supported independent learning can accelerate concept comprehension, especially for students who require more time to process the material (Fletcher & Lee, 2020: 67).

Motivation and Engagement

The use of technology increases student motivation to learn. In addition to making concepts easier to understand, technology makes learning more engaging and enjoyable. Unlike traditional methods, which are often monotonous, technology introduces variety into the learning process through simulations, videos, and interactive applications. This enhances student engagement and motivates them to participate more actively in the learning process (Davis, 2019: 30).

Support for Problem-Based Learning

Problem-based learning is an approach that involves students solving real-world problems using learned concepts. Digital technology supports this approach by offering resources that enable students to work on problems in a more structured and in-depth manner. In this study, some students reported that technology helped them solve mathematical problems more systematically and clearly (Roberts & Evans, 2022: 12).

Despite the significant improvements shown in student comprehension, there are several important factors to consider in technology-based learning:

Teacher Readiness

Teacher readiness to integrate technology into learning is crucial. Some teachers may feel underprepared or lack confidence in using digital tools effectively due to insufficient training. This can influence how effectively technology is utilized in classrooms. Previous studies have highlighted that challenges in implementing technology in class often stem from teachers' limited digital literacy (Newman & Harris, 2019: 82).

Access to Technology

Although SMAN 1 Terara has begun implementing digital technology in learning, access to adequate technological devices remains a challenge, especially in under-resourced areas. Some students expressed difficulties in accessing educational applications outside school hours due to limited devices or unstable internet connections. Therefore, efforts must be made to ensure all students have equal access

to technology to achieve optimal outcomes in technology-based mathematics learning (Miller & Sanchez, 2021: 15).

Based on the findings at SMAN 1 Terara, it can be concluded that the use of digital technology in mathematics education positively affects students' conceptual understanding. The results of the paired t-test showed a significant increase in scores between the pre-test and post-test, indicating that the integration of digital technology helps students grasp previously difficult concepts. These findings align with previous studies showing that digital technology enhances the quality of mathematics education through clearer visualization and increased interactivity (Zhao, 2022: 15; Kim & Park, 2023: 45).

The improvement in student understanding can be attributed to several factors. Digital tools such as interactive math applications and instructional videos allow students to learn independently and revisit material at their own pace, which has proven effective in improving comprehension (Lee & Kim, 2021: 30). Additionally, technology offers a more engaging learning experience, motivating students to participate more actively, which contributes to better learning outcomes (Fletcher & Lee, 2020: 67; Anderson & Brooks, 2021: 50).

However, despite the positive impact shown in this study, external factors such as teacher readiness and access to technology must be taken into account. The success of integrating technology in mathematics education greatly depends on the teacher's ability to effectively use it (Newman & Harris, 2019: 82). Moreover, the challenge of ensuring equal access to digital tools for all students must be addressed to ensure that every learner can benefit from technology in mathematics learning (Miller & Sanchez, 2021: 15).

This study provides important insights into how digital technology can improve students' understanding of mathematical concepts at the secondary level. For future research, it is recommended to expand the sample size and explore which types of technology are most effective in mathematics instruction. Furthermore, it is essential to develop policies that support the use of technology in schools, including teacher training programs and equitable distribution of digital devices.

Conclusion

This study demonstrates that the use of digital technology—such as interactive applications and instructional videos—significantly improves students' understanding of mathematical concepts at SMAN 1 Terara. The statistical tests showed a substantial increase in scores from the pre-test to the post-test after the technology was implemented. This indicates that technology can make mathematics learning more engaging, easier to understand, and encourage students to learn more independently and actively.

However, the success of technology use in learning is also influenced by teacher readiness and access to digital devices. Therefore, technological intervention cannot stand alone without sufficient support from the learning environment.

Recommendations

1. **Regular Teacher Training**
   Ongoing professional development for teachers is necessary to improve their skills in using educational technology so they can effectively integrate it into the teaching and learning process.
2. **Improved Technology Access**
   Schools must ensure that all students have access to digital devices and reliable internet connections, both at school and at home.
3. **Curriculum Integration of Technology**
   Mathematics learning materials should be redesigned with a digital approach in mind—such as through the development of interactive modules or problem-based learning supported by applications.
4. **Ongoing Mentorship and Evaluation**
   Schools should establish support teams to assist teachers and students in resolving technical issues and conduct regular evaluations of technology effectiveness in the classroom.
5. **Replication and Further Research**
   Similar studies should be conducted in other schools with larger and more diverse samples to assess the consistency of results and develop more effective and inclusive digital learning strategies.

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