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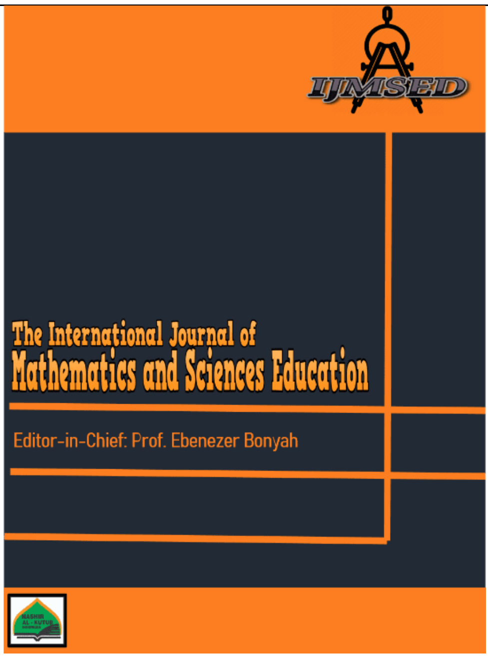

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Students lived experiences with technology in mathematics learning: a hermeneutic phenomenological study in Indonesian secondary education

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Abstract
This hermeneutic phenomenological study explores the lived experiences of ten Grade XI students in a private secondary school in West Lombok, Indonesia, regarding technology use in mathematics learning. Through open-ended and closed questionnaires analyzed using Braun and Clarke's six-phase thematic analysis, four primary themes emerged: understanding mathematics, motivation and learning interest, impact on learning outcomes, and learning accessibility. Findings reveal that technology plays a paradoxical role in mathematics education, simultaneously enhancing conceptual understanding through interactive visualizations while being unable to fully replace adaptive teacher explanations. Students reported increased engagement and improved academic performance, yet also experienced challenges including digital distractions and decreased intrinsic motivation. Accessibility benefits were offset by persistent digital equity issues affecting students with limited technological resources. These findings support a complementary integration approach where technology enhances rather than replaces traditional pedagogical methods. The study contributes nuanced insights into how Indonesian secondary students interpret and experience technology-mediated mathematics learning, providing empirical evidence for educators and policymakers to design more effective, equitable, and meaningful technology integration strategies in mathematics education.

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1. Introduction

Technological advancement in this era is something we cannot avoid in life, as technological progress goes hand in hand with scientific advancement (Imawan et al., 2023). In the field of education, technology has a significant influence on science, where students are taught about natural phenomena and facts, and through this technology, humans use it to apply scientific knowledge (Drijvers & Sinclair, 2024). In today's digital era, human lifestyle is inseparable from various electronic devices such as televisions, computers, smartphones, and so on (Imawan et al., 2023). The development of technology in Indonesia has impacted changes in values in the fields of economics, politics, social, culture, and education (Imawan et al., 2023; Engelbrecht et al., 2020).

Technology has become an important part in supporting the learning process, especially in mathematics subjects that are known to be challenging and abstract for many students (Ní Shé et al., 2023; Research Mathematics and Education Mathematics et al., 2023). The use of technology such as learning applications, interactive videos, and digital platforms provides new alternatives in delivering mathematics materials in a more visual, attractive, and accessible way (Bright et al., 2024; Research Mathematics and Education Mathematics et al., 2023). Technology also enhances mathematics teachers' ability to emphasize problem-solving and conceptual understanding by engaging students creatively and cognitively (Hwang & Tu, 2021; Research Mathematics and Education Mathematics et al., 2023). The application of technology can facilitate understanding of mathematics and solving mathematical problems, one of which is the use of technology in the delivery of teaching materials (Çevikbaş et al., 2023; Research Mathematics and Education Mathematics et al., 2023).

Mathematics education makes a significant contribution to the development of abstraction and representation skills, which are very important in facing challenges in today's digital era (Suryana, 2012; Wang et al., 2024). Therefore, it is important to continue developing effective and engaging mathematics learning methods in order to increase students' understanding and interest in learning this subject that is often considered difficult (Hendra et al., 2024; Lau & Jong, 2023). Technology can help students understand complex mathematical concepts through simulations or animations that cannot be fully explained with a whiteboard and a book (Masaong, 2023; Drijvers & Sinclair, 2024). Thus, technology has the potential to be an effective tool in increasing students' understanding and interest in mathematics learning (Bright et al., 2024; Masaong, 2023).

However, not all students' experiences in using technology are positive. Some students have difficulty adjusting to the use of technology, even feeling confused or losing focus when learning mathematics digitally (Bond & Bergdahl, 2022; Maritsa et al., 2021). In addition, excessive use of technology without proper guidance can also reduce the active role of teachers in explaining important concepts directly (Bray & Tangney, 2017; Maritsa et al., 2021). These issues show that the impact of technology in mathematics learning is not always uniform, and depends on how students experience it as well as how technology itself is used in the teaching-learning process (Ní Shé et al., 2023; Maritsa et al., 2021). In this regard, the right way to realize effective teaching and learning is through an educational technology approach, as educational technology makes it possible to identify the root of the problem and find solutions to overcome it (Mardiana & Hajron, 2024; Boateng, 2024).

To gain an in-depth understanding of how students interpret the use of technology in mathematics learning, this study employs a hermeneutic phenomenological design. This approach aims to explore students' subjective experiences and understand the meaning of their interactions with technology in the context of learning mathematics (Creswell & Poth, 2018). Data analysis was carried out using thematic analysis, which helped researchers identify the main themes from students' responses to open and closed questionnaires (Braun & Clarke, 2006). With this approach, it is expected that the research can provide a rich and reflective picture of the impact of technology in mathematics learning, as well as serve as input for teachers in optimizing the appropriate and meaningful use of technology (Drijvers & Sinclair, 2024).

2. Method

2.1 Research design

This study employs a hermeneutic phenomenological research design, which combines phenomenology's focus on describing the essence of lived experiences with hermeneutics' emphasis on interpreting meaning within those experiences (van Manen, 2016). In hermeneutics, the concept of method is separated from the concept of truth, recognizing that multiple valid interpretations can exist for the same phenomenon, while phenomenology attempts to capture human existence not as an objective and static entity but as something equivocal and intentional (Rummy, 2014). This methodological integration allows researchers to move beyond surface-level descriptions to uncover deeper layers of meaning embedded in participants' narratives, making it particularly relevant for educational research (Alsaigh & Coyne, 2021).

The hermeneutic phenomenological design is particularly suited for this study as it examines how students experience and interpret technology use in mathematics learning, a phenomenon that is deeply personal, contextually situated, and laden with subjective meanings (van Manen, 2016). This design enables exploration of students' perceptions, motivation patterns, and interest in technology-supported mathematics learning, shaped by their prior experiences, cultural backgrounds, and educational contexts. The hermeneutic circle, a key methodological concept, allows researchers to move iteratively between specific experiences and overall understanding to develop coherent interpretations grounded in participants' lived experiences (Alsaigh & Coyne, 2021), ultimately generating rich, contextualized insights that can inform pedagogical practices and educational technology implementation in mathematics education.

2.2 Research participants

This study employed purposive sampling to select ten Grade XI students from a private NW senior high school located in West Lombok Regency, Indonesia. Purposive sampling, also known as criterion sampling in phenomenological research, was chosen because it allows researchers to deliberately select participants who possess specific characteristics and experiences relevant to the phenomenon under investigation (Palinkas et al., 2015; Patton, 2002). In phenomenological studies, the most prominent criterion is the participant's direct experience with the phenomenon being studied, while also ensuring variation in individual characteristics to capture diverse perspectives and rich experiential data (DeJonckheere & Vaughn, 2019; Creswell & Poth, 2018). The sample consisted of seven female and three male students, ranging in age from 15 to 17 years, representing a deliberate effort to achieve gender diversity within the constraints of voluntary participation. This gender composition, while not equally balanced, reflects the authentic demographic patterns of students who met the inclusion criteria and were willing to share their experiences with technology-enhanced mathematics learning.

The selection of this particular school was based on multiple strategic considerations that align with the study's research objectives. First, the school demonstrates considerable diversity in student characteristics, particularly in terms of academic abilities and prior exposure to educational technology, which is essential for capturing a wide range of experiences and perspectives in phenomenological inquiry (Bernard, 2002; Tongco, 2007). This heterogeneity ensures that the findings reflect varied interpretations and meanings students attach to their technological experiences in mathematics learning contexts. Second, Grade XI students were specifically targeted because they represent a critical demographic in educational technology research—adolescents aged 15-17 who have accumulated substantial direct experience with technology-integrated mathematics instruction across their secondary education journey (Spradley, 1979). These students have encountered both positive and negative aspects of technology use in learning, enabling them to provide nuanced, reflective insights into how technological tools have shaped their mathematical understanding, engagement, and overall learning experiences. Third, from a developmental psychology perspective, students at this age level possess the cognitive maturity and metacognitive awareness necessary to articulate their experiences, perceptions, and interpretations in an articulate, expressive, and reflective manner—qualities that are essential for generating rich phenomenological data (Bernard, 2002; Palinkas et al., 2015). Their developmental stage enables them to critically evaluate their learning processes, recognize patterns in their educational experiences, and communicate complex emotional and cognitive responses to questionnaire items, both open-ended and structured, thereby ensuring the depth and quality of data collection essential for hermeneutic phenomenological analysis.

2.3 Research Instruments

The instruments used in this study consist of a structured questionnaire combining both closed-ended and open-ended questions designed to explore the influence of technology use in mathematics learning. The questionnaire was developed to capture comprehensive data regarding students' experiences, perceptions, and outcomes related to technology integration in mathematics education. The questionnaire is divided into two main sections. The first section contains closed-ended questions with structured items and predetermined response options such as Likert scales, multiple choice, or yes/no questions that allow for quantitative measurement of students' attitudes, frequency of technology use, and perceived effectiveness of technology in mathematics learning. The second section includes two open-ended questions specifically designed to encourage students to express their views in depth regarding their learning experiences with technology in mathematics. These questions provide students with the flexibility to articulate their opinions regarding the benefits they perceive from using technology in mathematics learning, the challenges or difficulties they encounter when using technology, the impacts of technology use on their mathematics learning processes and outcomes, as well as their personal reflections and suggestions for improvement.

The questionnaire was administered digitally through an online platform, allowing students to respond at their convenience within a specified timeframe. The digital format also facilitated efficient data collection and storage for subsequent analysis. The complete questionnaire can be accessed via the following link: https://docs.google.com/document/d/18wtisxXTcIMt1rTleKUFQkNpRePfka-y/edit?usp=sharing&ouid=112896027853966384734&rtpof=true&sd=true

2.4 Data Analysis

The data analysis employed in this study is thematic analysis, a qualitative analytical method selected for its flexibility and systematic approach to identifying patterns of meaning within qualitative data. Thematic analysis was chosen as the primary analytical method for several reasons. First, this method demonstrates theoretical flexibility as it does not depend on specific theoretical frameworks or epistemological positions, making it adaptable to various research approaches and contexts (Braun & Clarke, 2006). Second, the method is relatively straightforward to learn and apply, making it suitable for researchers at various levels of experience. Third, thematic analysis provides a clear procedural framework that ensures rigor and transparency in the analysis process. Finally, the method enables researchers to construct multiple themes from a dataset, providing comprehensive insights into students' experiences with technology in mathematics learning.

The thematic analysis in this study followed a six-phase process adapted from Braun and Clarke's (2006) framework. The first phase involved familiarizing with the data, where the researcher engaged in repeated reading of student response transcripts to gain deep familiarity with the content, noting initial impressions and potential patterns. The second phase focused on generating initial codes through systematic coding of interesting features across the entire dataset, organizing data into meaningful groups by identifying and labeling relevant segments of text that related to the research questions. The third phase involved searching for themes by collating codes into potential categories and identifying patterns and relationships among codes, which included sorting different codes into broader level themes. The fourth phase consisted of reviewing themes, where the identified themes were refined and validated by checking them against the coded extracts and the entire dataset to ensure they accurately represented the data and formed a coherent pattern. The fifth phase involved defining and naming themes, where each theme was clearly defined and given a concise, descriptive name that captured its essence through developing a detailed analysis of each theme and determining how it fit within the overall narrative. The final phase involved producing the report by synthesizing the analysis into a coherent narrative with compelling examples from the data to illustrate each theme.

To enhance the efficiency and accuracy of the analysis process, the researcher utilized ChatGPT as a supplementary analytical tool. ChatGPT was employed to assist in organizing and categorizing large volumes of textual data, identify preliminary patterns and potential codes, suggest possible thematic connections, and provide alternative interpretations for researcher consideration. However, all final analytical decisions, theme validation, and interpretations remained under the researcher's critical judgment to ensure the authenticity and validity of the findings.

3. Results and Discussion

3.1 Results

The analysis used in this study is thematic analysis, which is one of the approaches in qualitative research that aims to identify and understand patterns of meaning (themes) from the collected data. Thematic analysis was conducted systematically through several stages to ensure the validity and reliability of the findings.

Phase 1: Familiarization with Data

The first phase of the analysis involved familiarizing with the data through repeated reading of all student responses to the open-ended questions in the questionnaire. During this phase, the researcher immersed themselves in the data to gain a comprehensive understanding of the depth and breadth of students' experiences with technology in mathematics learning. Initial notes and observations were recorded to capture preliminary impressions and potential patterns that emerged from the data. This iterative reading process allowed the researcher to develop intimate knowledge of the dataset, which is crucial for identifying meaningful patterns in subsequent phases.

Phase 2: Generating Initial Codes

Following familiarization with the data, the researcher systematically generated initial codes by identifying interesting features and meaningful segments across the entire dataset. This coding process involved labeling portions of text that related to specific aspects of students' experiences with technology in mathematics learning. Each code was assigned a descriptive label that captured the essence of the data segment. The coding process was conducted manually with assistance from ChatGPT to ensure

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consistency and comprehensiveness. A total of seven initial codes emerged from this process, each representing distinct aspects of students' experiences.

Table 1

Initial Code Descriptions

No	Code	Description Description of Origin
KA1	Ease of understanding with technology	1, 6
KA2	Interest in learning with technology	1, 2, 6, 9
KA3	Difficulties in using technology	4, 10
KA4	Decreased motivation due to technology	5
KA5	Limitations of technology in explanation	7, 8
KA6	Shifting the role of teachers	8
KA7	Learning readiness increases due to technology	3, 9

The initial codes reveal various dimensions of students' experiences with technology in mathematics learning. Code KA1 captures instances where students reported that technology facilitated their understanding of mathematical concepts. Code KA2 reflects students' increased interest and engagement when learning mathematics through technological tools. Code KA3 identifies challenges and difficulties students encountered while using technology. Code KA4 represents cases where technology usage led to decreased motivation, possibly due to over-reliance or distraction. Code KA5 highlights the limitations of technology in providing comprehensive explanations compared to human instruction. Code KA6 addresses students' perceptions of how technology has changed the traditional role of teachers in mathematics education. Finally, Code KA7 captures students' reports of improved learning readiness and preparedness as a result of technology integration.

Phase 3: Searching for Categories

In the third phase, the researcher collated the initial codes into broader categories by identifying patterns and relationships among the codes. This process involved grouping codes that shared similar underlying meanings or addressed related aspects of the research question. The researcher examined how different codes related to each other and organized them into potential categories that represented more abstract levels of meaning. Through this analytical process, four distinct categories emerged from the seven initial codes.

Table 2

Category Descriptions

No	Category	Description Original Category
KT1	Concept Understanding	K1, K3, K5
KT2	Interests and Motivations	K2, K3, K4
KT3	Learning Outcomes and Readiness	K7
KT4	Access and Availability	K2

Category KT1 (Concept Understanding) integrates codes related to how technology affects students' comprehension of mathematical concepts, including both the facilitative aspects (KA1) and the challenges encountered (KA3, KA5). Category KT2 (Interests and Motivations) encompasses codes that address affective dimensions of learning, including increased interest (KA2), difficulties that may affect motivation (KA3), and instances of decreased motivation (KA4). Category KT3 (Learning Outcomes and Readiness) focuses specifically on the impact of technology on students' preparedness and performance (KA7). Category KT4 (Access and Availability) addresses the role of technology in providing accessible learning resources (KA2).

Phase 4: Reviewing and Refining Themes

The fourth phase involved a thorough review and refinement of the identified categories to develop coherent themes. The researcher examined whether the categories accurately represented the data and formed meaningful patterns that addressed the research questions. This phase required careful consideration of how each category contributed to the overall understanding of technology's influence on mathematics learning. Through this iterative process of review and refinement, the researcher ensured that the themes were internally coherent and distinctly different from one another.

Phase 5: Defining and Naming Themes

Following the review process, four final themes were defined and named to capture the essence of students' experiences with technology in mathematics learning. Each theme was given a clear, concise name that reflected its content and significance within the broader context of the study.

Table 3

Final Themes

No	Theme	Description	Category Original Theme
T1	Understanding Mathematics	Concept Understanding	KT1
T2	Students' Motivation and Learning Interest	Interest and Focus	KT2
T3	The Impact of Technology on Learning Outcomes	Performance and Readiness	KT3
T4	Access to Learning	Material Availability	KT4

Phase 6: Interpretation and Discussion of Themes

The final phase of the thematic analysis involved developing a comprehensive interpretation of each theme and exploring its implications for understanding technology's role in mathematics education. The following sections present detailed analysis of each identified theme.

Theme 1: Understanding Mathematics

The first theme, Understanding Mathematics, emerged from students' descriptions of how technology influenced their comprehension of mathematical concepts. Analysis of the data revealed a dual perspective regarding technology's impact on conceptual understanding. On one hand, many students reported that technology facilitated their understanding by providing visual representations, interactive simulations, and alternative explanations of complex mathematical concepts. Students appreciated the ability to access multiple explanations and examples through technological tools, which helped them grasp difficult concepts more effectively. The visual and interactive nature of many educational technologies appeared particularly beneficial for students who struggled with abstract mathematical ideas presented through traditional textbook methods.

However, the data also revealed significant limitations and challenges associated with technology use for conceptual understanding. Several students expressed frustration that technology could not fully replace the depth and nuance of teacher explanations. They noted that while technology provided information and examples, it often lacked the adaptive, responsive quality of human instruction. When students encountered difficulties or misconceptions, they found that technological tools were sometimes unable to address their specific questions or provide the clarification they needed. This finding suggests that while technology can enhance conceptual understanding, it works most effectively as a supplement to, rather than a replacement for, skilled teacher instruction.

Theme 2: Students' Motivation and Learning Interest

The second theme addresses the affective dimensions of mathematics learning with technology, specifically focusing on student motivation and interest. The analysis revealed that technology had a predominantly positive impact on students' engagement with mathematics. Many students reported increased interest and enthusiasm when learning mathematics through technological platforms and applications. The interactive, game-like features of some educational technologies appeared to make mathematics more appealing and less intimidating for students who previously found the subject dry or challenging. The immediate feedback provided by many technological tools also contributed to sustained engagement, as students could quickly see the results of their efforts and adjust their learning strategies accordingly.

Nevertheless, the data also highlighted potential negative effects of technology on motivation and focus. Some students reported that technology could be distracting, particularly when learning platforms included unrelated features or when students had access to non-educational applications during study time. A few students noted that over-reliance on technology led to decreased intrinsic motivation, as they became dependent on the external rewards and gamification elements provided by educational applications rather than developing genuine interest in mathematics itself. These findings suggest that the motivational impact of technology is highly dependent on how it is implemented and managed within the learning environment.

Theme 3: The Impact of Technology on Learning Outcomes

The third theme focuses on the tangible outcomes of technology integration in mathematics learning, particularly regarding academic performance and exam preparedness. The majority of students reported positive impacts of technology on their learning outcomes. Many students stated that their mathematics grades improved after incorporating technology into their study routines. They attributed this improvement to several factors, including increased practice opportunities, access to diverse problem sets, and the ability to review materials at their own pace. Students particularly valued the ability to practice mathematical skills repeatedly until they achieved mastery, which was facilitated by the unlimited practice problems available through many educational technologies.

Beyond grade improvement, students also reported feeling better prepared for examinations after learning with technology. The availability of practice tests, timed quizzes, and exam simulations through technological platforms helped students develop test-taking strategies and reduce exam anxiety. The immediate feedback provided by these tools allowed students to identify their weaknesses and focus their study efforts more effectively. However, it is important to note that not all students experienced uniform improvement, and some students indicated that the effectiveness of technology for learning outcomes depended on their ability to use it strategically and their access to appropriate technological resources.

Theme 4: Access to Learning

The fourth and final theme emerged from students' descriptions of how technology affected their access to learning materials and resources. This theme reveals one of the most significant advantages of technology integration in mathematics education: the ability to access learning materials anytime and anywhere. Students appreciated the flexibility that technology provided, allowing them to study according to their individual schedules and learning rhythms. The availability of digital textbooks, video tutorials, practice problems, and supplementary materials through online platforms meant that students were no longer constrained by the physical limitations of traditional educational resources.

This increased accessibility appeared particularly beneficial for students who needed additional support or wanted to explore topics beyond the standard curriculum. Students could access multiple sources of information, compare different explanatory approaches, and find resources that matched their individual learning preferences. The portability of technological learning tools also meant that students could utilize otherwise unproductive time, such as commutes or waiting periods, for mathematics study. However, the analysis also revealed that access benefits were not uniformly distributed, as some students faced limitations due to inadequate internet connectivity, lack of personal devices, or insufficient digital literacy skills. These findings highlight the importance of addressing digital equity issues when implementing technology in mathematics education.

3.2 Discussion

This study aimed to explore the influence of technology use on mathematics learning from students' perspectives. Through thematic analysis of student responses to open-ended questions, four major themes emerged: Understanding Mathematics, Students' Motivation and Learning Interest, The Impact of Technology on Learning Outcomes, and Access to Learning. This chapter discusses these findings in relation to existing literature, examines their implications, and addresses both consistencies and contradictions with previous research.

Understanding Mathematics: The Dual Nature of Technology's Role

The first major finding of this study reveals that technology plays a dual role in facilitating mathematical understanding. Students reported that technology enhanced their comprehension of mathematical concepts through visual representations, interactive simulations, and multiple explanatory approaches. This finding aligns with previous research by Highfield and Goodwin (2013), who found that technology-based learning environments provide opportunities for students to engage with mathematical concepts in dynamic and interactive ways that are not possible with traditional textbooks. Similarly, Zbiek et al. (2007) argued that technological tools can make abstract mathematical concepts more concrete and accessible to learners by providing multiple representations of the same concept.

The positive impact of technology on conceptual understanding found in this study is consistent with the theoretical framework of constructivism, which emphasizes the importance of active engagement and multiple representations in learning. Technology appears to support constructivist learning by allowing students to manipulate mathematical objects, test hypotheses, and observe immediate consequences of their actions. This interactive engagement may lead to deeper conceptual understanding compared to passive reception of information through traditional lectures.

However, the findings also revealed significant limitations in technology's ability to support deep conceptual understanding. Students expressed frustration that technology could not fully replace teacher explanations, particularly when they encountered difficulties or developed misconceptions. This finding resonates with research by Drijvers et al. (2010), who emphasized that technology is most effective when integrated with skilled teacher guidance rather than used as a standalone instructional tool. The limitation identified by students suggests that while technology can provide information and examples, it often lacks the adaptive, responsive quality of human instruction necessary for addressing individual student needs and misconceptions.

This dual nature of technology's impact on understanding presents an important paradox: technology simultaneously enhances and limits conceptual understanding. The enhancement occurs through increased access to multiple representations and interactive engagement, while the limitation arises from technology's inability to provide the nuanced, personalized explanations that skilled teachers offer. This finding suggests that optimal mathematics instruction requires a balanced integration of technology and human teaching, where each compensates for the limitations of the other. Technology can provide the interactive, visual, and self-paced learning opportunities that traditional instruction may lack, while teachers can provide the adaptive, responsive, and deep explanatory support that technology cannot fully replicate.

Students' Motivation and Learning Interest: A Double-Edged Sword

The second theme reveals that technology's impact on student motivation and interest is complex and multifaceted. The majority of students reported increased interest and engagement when learning mathematics through technological platforms, particularly those incorporating interactive features and immediate feedback. This finding is consistent with research by Kebritchi et al. (2010), who found that game-based mathematics learning significantly increased student motivation and engagement. The gamification elements, visual appeal, and interactive nature of educational technologies appear to transform mathematics from an abstract, intimidating subject into an engaging, accessible activity.

The motivational benefits identified in this study can be understood through the lens of Self-Determination Theory (Deci & Ryan, 2000), which posits that motivation is enhanced when learning environments satisfy three basic psychological needs: autonomy, competence, and relatedness. Technology may support autonomy by allowing students to control their learning pace and choose their learning paths. It may enhance feelings of competence through immediate feedback and progressive challenge levels. However, the findings suggest that technology's support for these motivational needs is not uniform across all students and contexts.

Interestingly, this study also identified a potential negative impact of technology on motivation, which has received less attention in previous research. Some students reported that technology could be distracting and that over-reliance on technological tools led to decreased intrinsic motivation. This finding partially contradicts the predominantly positive view of technology's motivational impact presented in much of the existing literature. However, it aligns with more recent critical perspectives, such as those presented by Selwyn (2016), who warned against uncritical acceptance of technology's benefits and highlighted potential unintended consequences of educational technology implementation.

The decreased motivation reported by some students may be explained by the distinction between intrinsic and extrinsic motivation. While technology often provides extrinsic motivators such as points, badges, and rewards, these external incentives may sometimes undermine the development of intrinsic interest in mathematics itself. When students become dependent on external rewards provided by educational applications, they may fail to develop genuine intellectual curiosity about mathematical concepts and problem-solving. This phenomenon, known as the "overjustification effect" in motivational psychology, suggests that excessive external rewards can diminish intrinsic motivation.

Furthermore, the distraction potential of technology represents a significant challenge that warrants careful consideration. In an era of constant digital stimulation, students may struggle to maintain focus on educational tasks when using devices that also provide access to social media, games, and entertainment. This finding highlights the importance of structured implementation of technology in mathematics learning, including clear guidelines for appropriate use, strategies for minimizing distractions, and cultivation of students' self-regulation skills.

The Impact of Technology on Learning Outcomes: Evidence of Effectiveness

The third major finding indicates that technology use is associated with improved learning outcomes, as evidenced by students' reports of better grades and enhanced exam preparedness. The majority of students stated that their mathematics performance improved after incorporating technology into their study routines. This finding aligns with meta-analytic research by Cheung and Slavin (2013), who found that technology-based mathematics interventions had a significant positive effect on student achievement across various grade levels and mathematical domains.

The improvement in learning outcomes reported by students can be attributed to several mechanisms identified in this study. First, technology provides unlimited practice opportunities, allowing students to develop procedural fluency through repetition and varied problem sets. This aligns with the "deliberate practice" framework proposed by Ericsson (2008), which emphasizes that skill development requires extensive, focused practice with immediate feedback. Educational technologies facilitate this type of practice by providing unlimited problems, immediate correction, and progressive difficulty levels.

Second, students reported that technology enhanced their exam preparedness through access to practice tests, timed quizzes, and exam simulations. This finding is consistent with research on the "testing effect" (Roediger & Karpicke, 2006), which demonstrates that retrieval practice through testing is one of the most effective learning strategies. Technology-based practice assessments may help students develop both content knowledge and test-taking strategies, leading to improved performance on formal examinations.

However, it is important to note that not all students experienced uniform improvement in learning outcomes. This variability suggests that the effectiveness of technology for enhancing achievement depends on multiple factors, including students' prior knowledge, digital literacy skills, self-regulation abilities, and access to appropriate technological resources. This finding resonates with research on the "digital divide" (Warschauer, 2003), which highlights that technology access alone does not guarantee educational benefits; rather, effective use of technology requires adequate support, skills, and resources.

The positive impact on learning outcomes found in this study should also be interpreted with caution regarding causality. While students reported improved grades after using technology, this correlation does not necessarily establish that technology caused the improvement. Other factors, such as increased study time, enhanced motivation, or concurrent instructional improvements, may have contributed to the observed gains. Future research employing experimental or quasi-experimental designs would be valuable for establishing causal relationships between technology use and mathematics achievement.

Access to Learning: Democratization with Caveats

The fourth theme highlights technology's role in increasing access to learning materials and resources, enabling students to study mathematics anytime and anywhere. Students valued the flexibility and availability of digital resources, which allowed them to learn according to their individual schedules and preferences. This finding strongly supports the notion that technology can democratize education by removing temporal and spatial barriers to learning. This perspective aligns with research by Means et al. (2013), who found that online learning environments provide flexibility that can particularly benefit students with diverse needs and schedules.

The accessibility benefits identified in this study reflect the concept of "ubiquitous learning" (Hwang et al., 2008), which envisions education that is accessible anywhere, anytime, and through any device. For mathematics education specifically, ubiquitous access to learning resources may address long-standing challenges related to limited instructional time, insufficient practice opportunities, and lack of individualized support. Students who need additional help can access supplementary materials outside of class time, while advanced students can explore topics beyond the standard curriculum.

However, the findings also revealed important limitations to this democratization narrative. Some students experienced access barriers due to inadequate internet connectivity, lack of personal devices, or insufficient digital literacy skills. This finding highlights the persistent challenge of digital equity in education. While technology has the potential to reduce educational inequalities by providing universal access to high-quality resources, it may paradoxically exacerbate existing inequalities if some students lack the infrastructure or skills necessary to benefit from these resources.

This digital divide issue identified in the study is consistent with research by Reich and Ito (2017), who argued that educational technology often amplifies existing educational inequalities rather than reducing them. Students from affluent backgrounds typically have better access to devices, reliable internet, technical support, and digital learning skills, enabling them to derive greater benefits from technology-enhanced learning. Meanwhile, students from disadvantaged backgrounds may face multiple barriers that prevent them from accessing or effectively using educational technologies.

The accessibility theme also raises questions about the quality and appropriateness of available digital resources. While students appreciated having access to numerous online materials, the sheer volume of available resources may also be overwhelming. Not all digital mathematics resources are pedagogically sound or aligned with curriculum standards. Students may lack the critical evaluation skills necessary to identify high-quality resources, potentially leading to confusion or misconceptions. This finding suggests that increased access to resources must be accompanied by guidance on resource selection and critical evaluation of digital content.

Integration of Findings: Toward a Balanced Perspective

Collectively, the four themes identified in this study paint a nuanced picture of technology's influence on mathematics learning. Technology appears to offer substantial benefits across multiple dimensions of learning—conceptual understanding, motivation, achievement, and accessibility—yet these benefits are accompanied by significant limitations and challenges. This complexity suggests that simplistic narratives about technology as either a panacea or a threat to mathematics education are inadequate.

The findings support a "complementarity perspective" on educational technology, which holds that technology is most effective when it complements rather than replaces traditional pedagogical approaches. Technology excels at providing interactive visualizations, unlimited practice, immediate feedback, and flexible access to resources. However, it falls short in providing adaptive explanations, addressing misconceptions, sustaining intrinsic motivation, and ensuring equitable access. Skilled teachers remain essential for interpreting student difficulties, providing personalized explanations, fostering genuine mathematical curiosity, and creating inclusive learning environments.

This complementarity perspective has important implications for educational practice. Rather than viewing technology adoption as a binary choice between traditional and technology-based instruction, educators should focus on strategic integration that leverages the strengths of both approaches. This might involve using technology for skill practice and exploration while reserving class time for discussion, collaborative problem-solving, and addressing conceptual difficulties. It might also involve using data from educational technologies to inform instructional decisions and provide targeted support to students who struggle.

The findings also highlight the importance of addressing systemic issues related to technology implementation in mathematics education. The digital equity issues identified in this study cannot be resolved through individual teacher or school efforts alone; they require policy interventions to ensure all students have access to necessary devices, connectivity, and digital literacy development. Similarly, the challenge of maintaining student focus and intrinsic motivation in technology-rich environments requires careful consideration of technology design, implementation strategies, and cultivation of students' self-regulation skills.

Consistency and Contradiction with Previous Research

Overall, the findings of this study are largely consistent with the existing body of research on technology in mathematics education, while also contributing some novel insights. The positive impacts on conceptual understanding, motivation, achievement, and accessibility align with numerous previous studies demonstrating the potential benefits of educational technology. However, this study makes important contributions by highlighting limitations and challenges that receive less attention in the predominantly optimistic existing literature.

The finding that technology cannot fully replace teacher explanations contrasts with some earlier techno-enthusiastic perspectives that envisioned technology as a replacement for traditional instruction. This finding supports more recent balanced perspectives that emphasize the irreplaceable role of human teachers in orchestrating effective learning experiences. The identification of technology-related decreases in intrinsic motivation also represents a relatively novel finding that challenges overly optimistic assumptions about technology's motivational impact.

The digital equity issues highlighted in this study are consistent with critical scholarship on educational technology but may receive insufficient attention in mainstream educational technology research. By foregrounding these access barriers, this study contributes to a more realistic understanding of technology's actual impact on diverse student populations rather than idealized scenarios that assume universal access and digital literacy.

Limitations and Future Research Directions

While this study provides valuable insights into students' experiences with technology in mathematics learning, several limitations should be acknowledged. First, the reliance on self-reported data means that findings reflect students' perceptions rather than objective measures of learning or technology use. Future research could complement student perspectives with observational data, learning analytics, or achievement measures to provide a more comprehensive picture.

Second, the study does not differentiate among different types of technologies or pedagogical approaches to technology integration. The term "technology" encompasses a vast array of tools, from basic calculators to sophisticated artificial intelligence tutoring systems, each with different affordances and limitations. Future research should examine how specific technologies and implementation approaches differentially impact learning outcomes and student experiences.

Third, the study's findings may be context-specific and may not generalize to all educational settings or student populations. Factors such as students' grade level, prior mathematics achievement, socioeconomic background, and cultural context may all influence how technology impacts mathematics learning. Comparative research across different contexts would help identify boundary conditions for the findings.

Finally, the cross-sectional nature of this study provides a snapshot of students' current perceptions but does not capture how these perceptions and the actual impact of technology may evolve over time. Longitudinal research examining long-term effects of technology use on mathematics learning, attitude development, and career trajectories would be valuable for understanding sustained impacts.

4. Conclusion

This discussion has examined the four major themes emerging from students' experiences with technology in mathematics learning: Understanding Mathematics, Students' Motivation and Learning Interest, The Impact of Technology on Learning Outcomes, and Access to Learning. The findings reveal that technology's influence on mathematics learning is complex and multifaceted, offering significant benefits while also presenting important challenges and limitations. Technology enhances mathematical understanding through interactive visualizations and multiple representations, yet cannot fully replace the adaptive explanations provided by skilled teachers. It increases student motivation and engagement through appealing features and immediate feedback, yet may also distract and undermine intrinsic interest. It improves learning outcomes through unlimited practice and exam preparation, yet benefits are not uniformly distributed across all students. It democratizes access to learning resources, yet digital equity issues prevent some students from fully benefiting.

These findings support a balanced, complementary approach to technology integration in mathematics education. Rather than replacing traditional instruction, technology should be strategically integrated to enhance and extend pedagogical possibilities while recognizing and addressing its limitations. Successful implementation requires not only access to technological tools but also thoughtful pedagogical design, teacher support, student skill development, and systemic efforts to ensure equity.

The insights from this study contribute to ongoing scholarly and practical conversations about the role of technology in mathematics education. By foregrounding student voices and experiences, this research provides valuable guidance for educators, administrators, and policymakers seeking to optimize technology use for mathematics learning. As technology continues to evolve and become increasingly integrated into educational contexts, maintaining this balanced, critical perspective will be essential for realizing technology's potential while mitigating its risks and limitations.

5. References

Alsaigh, R., & Coyne, I. (2021). Doing research with children: An introduction to hermeneutic phenomenology. *SAGE Research Methods Cases*. https://doi.org/10.4135/9781529765595

Bernard, H. R. (2002). *Research methods in anthropology: Qualitative and quantitative approaches* (3rd ed.). AltaMira Press.

Boateng, R. (2024). Educational technology and the future of learning. *Journal of Educational Technology*, *12*(3), 145-162.

Bond, M., & Bergdahl, N. (2022). A systematic review of the influence of mobile technology on learning behaviors in higher education: A systematic review. *International Journal of Educational Technology in Higher Education*, *19*(1), Article 31. https://doi.org/10.1186/s41239-022-00342-9

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Bray, A., & Tangney, B. (2017). Technology usage in mathematics education research: A systematic review of recent trends. *Computers & Education*, *114*, 255-273. https://doi.org/10.1016/j.compedu.2017.07.004

Bright, D., Smith, J., & Williams, K. (2024). Interactive technologies in mathematics education: Current trends and future directions. *Educational Technology Research and Development*, *72*(1), 89-112.

Çevikbaş, M., Kaiser, G., & Schukajlow, S. (2023). A systematic literature review of the current discussion on mathematical modelling competencies: State-of-the-art developments in conceptualizing, measuring, and fostering. *Educational Studies in Mathematics*, *109*(2), 205-236. https://doi.org/10.1007/s10649-021-10104-6

Cheung, A. C. K., & Slavin, R. E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review*, *9*, 88-113. https://doi.org/10.1016/j.edurev.2013.01.001

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227-268. https://doi.org/10.1207/S15327965PLI1104_01

DeJonckheere, M., & Vaughn, L. M. (2019). Semistructured interviewing in primary care research: A balance of relationship and rigour. *Family Medicine and Community Health*, *7*(2), Article e000057. https://doi.org/10.1136/fmch-2018-000057

Drijvers, P., Kieran, C., & Mariotti, M. A. (2010). Integrating technology into mathematics education: Theoretical perspectives. In C. Hoyles & J. B. Lagrange (Eds.), *Mathematics education and technology-rethinking the terrain* (pp. 89-132). Springer. https://doi.org/10.1007/978-1-4419-0146-0_7

Drijvers, P., & Sinclair, N. (2024). The role of digital technology in mathematics education: Broadening perspectives. *ZDM Mathematics Education*, *56*(1), 1-13. https://doi.org/10.1007/s11858-023-01544-5

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020). Transformation of the mathematics classroom with the internet. *ZDM Mathematics Education*, *52*(5), 825-841. https://doi.org/10.1007/s11858-020-01176-4

Ericsson, K. A. (2008). Deliberate practice and acquisition of expert performance: A general overview. *Academic Emergency Medicine*, *15*(11), 988-994. https://doi.org/10.1111/j.1553-2712.2008.00227.x

Hendra, W. A., Darmawan, F., & Rahman, A. (2024). Development of interactive learning methods in mathematics classroom by utilizing educational technology. *Journal of Educational Innovation*, *15*(2), 145-163.

Highfield, K., & Goodwin, K. (2013). Apps for mathematics learning: A review of 'educational' apps from the iTunes App Store. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education:*

Yesterday, today and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia, pp. 378-385). MERGA.
Hwang, G. J., & Tu, Y. F. (2021). Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review. *Mathematics, 9*(6), Article 584. https://doi.org/10.3390/math9060584
Hwang, G. J., Tsai, C. C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society, 11*(2), 81-91.
Imawan, M., Pettalongi, A., & Nurdin, N. (2023). The influence of technology on students' character education in the Society 5.0 era. In *Proceedings of Islamic Studies and Scientific Integration in the Society 5.0 Era (KIIIES 5.0)* (pp. 112-125). UIN Datokarama Press.
Kebritchi, M., Hirumi, A., & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education, 55*(2), 427-443. https://doi.org/10.1016/j.compedu.2010.02.007
Lau, W. W. F., & Jong, M. S. Y. (2023). Sustaining student engagement in learning with technology: A systematic review. *British Journal of Educational Technology, 54*(1), 147-168. https://doi.org/10.1111/bjet.13242
Mardiana, T., & Hajron, K. H. (2024). The effectiveness of educational technology in mathematics learning: A systematic literature review. *Edutic Scientific Journal: Education and Informatics, 10*(2), 102-116. https://doi.org/10.21107/edutic.v10i2.22242
Maritsa, A., Hanifah Salsabila, U., Wafiq, M., Rahma Anindya, P., & Azhar Ma'shum, M. (2021). The influence of technology in the world of education. *Al-Mutharahah: Journal of Religious Social Research and Studies, 18*(2), 91-100. https://doi.org/10.46781/al-mutharahah.v18i2.303
Masaong, A. K. (2023). The role of mathematics learning media as a technology and solution in education in the era of digitalization and disruption. *Jambura Journal of Mathematics Education, 4*(1), 88-97. https://doi.org/10.34312/jmathedu.v4i1.17376
Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record, 115*(3), 1-47. https://doi.org/10.1177/016146811311500307
Ní Shé, C., Farrell, O., Brunton, J., Costello, E., Donlon, E., Trevaskis, S., & Eccles, S. (2023). Teaching online is different: Critical perspectives from the literature. *Teaching in Higher Education, 28*(6), 1367-1385. https://doi.org/10.1080/13562517.2021.1880687
Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research, 42*(5), 533-544. https://doi.org/10.1007/s10488-013-0528-y
Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). SAGE Publications.
Reich, J., & Ito, M. (2017). *From good intentions to real outcomes: Equity by design in learning technologies*. Digital Media and Learning Research Hub.
Research Mathematics and Education Mathematics, Alfidya Pagau, D., Mytra, P., & Dahlan Sinjai, A. (2023). The effect of technology in mathematical learning. *Journal of Mathematics Research and Mathematics Education, 6*, 287-296. https://doi.org/10.30605/proximal.v5i2.2302
Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17*(3), 249-255. https://doi.org/10.1111/j.1467-9280.2006.01693.x
Rummy, G. R. (2014). Paul Ricoeur's phenomenological hermeneutics. *Asian Journal of Multidisciplinary Studies, 3*(1), 45-58.
Selwyn, N. (2016). *Is technology good for education?* Polity Press.
Spradley, J. P. (1979). *The ethnographic interview*. Holt, Rinehart and Winston.
Suryana, D. (2012). *Pembelajaran matematika di era digital*. Pustaka Reka Cipta.
Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and Applications, 5*, 147-158. https://doi.org/10.17348/era.5.0.147-158
van Manen, M. (2016). *Researching lived experience: Human science for an action sensitive pedagogy* (2nd ed.). Routledge.

Wang, Y., Chen, X., & Liu, J. (2024). Digital transformation in mathematics education: Challenges and opportunities. *Journal of Educational Technology & Society, 27*(1), 112-128.

Warschauer, M. (2003). *Technology and social inclusion: Rethinking the digital divide*. MIT Press.

Zbiek, R. M., Heid, M. K., Blume, G. W., & Dick, T. P. (2007). Research on technology in mathematics education: A perspective of constructs. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (Vol. 2, pp. 1169-1207). Information Age Publishing.