Malaysian Journal of Computing, 11 (1): 2469-2485, 2026

eISSN: 2600-8238

TEACHER READINESS AND ATTITUDES TOWARD DIGITAL TECHNOLOGY IN MATHEMATICS CLASSROOMS

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ABSTRACT

This study explores how digital technology is integrated into mathematics education, focusing on the views of secondary school mathematics teachers and using a quantitative research method through a survey. Descriptive and inferential statistical analyses were performed to examine the factors influencing technology adoption, identify its barriers, and suggest strategies for enhancement. The novelty of this study lies in its development of an integrated perspective that simultaneously examines teachers' readiness, experiential background, and attitudes alongside systemic constraints such as training, resource availability, and institutional support within the context of mathematics education. However, challenges such as inadequate training, limited resources, and lack of institutional support impede effective implementation. Therefore, to overcome the issues, the study seeks the perceptions of 108 mathematics teachers in secondary schools using a questionnaire based on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The study contributes to existing literature by offering empirical evidence on the interconnected nature of these factors and by proposing targeted, context-specific strategies to enhance digital integration in mathematics classrooms. Key recommendations include tailored professional development programs, the promotion of collaborative learning environments, and better infrastructure to equip teachers with the necessary skills and resources for smooth technological integration. By addressing the challenges, educators can foster more enriching teaching and learning experiences in mathematics, ultimately improving outcomes in the digital era.

Keywords: *Digital technology, Mathematics, Teacher Readiness.*

Received for review: 15-10-2026; Accepted: 02-04-2026; Published: 10-04-2026
DOI: 10.24191/mjoc.vo11i1.6401

1. Introduction

Integrating the Internet and digital technologies into education has become increasingly widespread, making it an essential component of modern teaching and learning. Digitalization in education systems worldwide has led many countries to enact legislation and action plans to accelerate digital technology adoption, aiming to simplify tasks and enhance various aspects of life, including education (Viberg *et al*., 2023). Technology is the catalyst for innovation in teaching, offering diverse learning experiences and expanding educational opportunities across disciplines, including mathematics. Tools such as presentation slides (Othman *et al*., 2017), instructional videos on YouTube (Zawawi *et al*., 2023), GeoGebra (Idham *et al*., 2024), Adobe Flash Player (Mahat *et al*., 2018), and online learning platforms such as Quizziz, Worldwall, Kahoot (Rosni *et al*., 2024) enable teachers to connect mathematics to real-world context effectively, fostering conceptual understanding, motivation, and collaboration among students.

In addition, using technology to learn mathematics makes it more interesting, motivates students, provides opportunities for learning while playing, and encourages students to investigate problems, make guesses, increase opportunities for collaboration, and seek explanations while sharing their findings with their peers and teachers. All educators should compile learning materials thoroughly and systematically to ensure that instruction is interactive, inspiring, enjoyable, challenging, and designed to encourage student participation (Putri *et al*., 2020).

The role of educators in the contemporary educational background increases past traditional teaching, as they are instrumental in shaping students' learning experiences (Othman *et al*., 2024). The broad range of digital technology available today has also significantly risen with advanced capabilities and power compared to previous years. Considering these changes, the research focus of many has moved from how computers help with learning to how teachers can practically use different types of digital technology to provide students with activities for enhancing mathematical learning (Clark-Wilson *et al*., 2020; Che Mansor & Rosly, 2024).

However, while technology holds significant potential for improving mathematics education, its integration faces challenges. Teachers must possess digital literacy and competence to utilize tools effectively in instruction. Despite the benefits of digital technologies, including enhanced engagement and opportunities for collaborative learning, many secondary school teachers struggle to implement these tools. Limited training, inadequate resources, and perceived difficulty in integrating mathematical topics with technology are significant barriers (Ilomäki & Lakkala, 2018; Muhazir & Retnawati, 2020). Furthermore, teachers' limited use of digital tools often reduces their effectiveness, as they are commonly employed as supplementary aids rather than transformative tools (Viberg *et al*., 2023). Addressing these challenges requires teachers to embrace innovative pedagogical methods and actively integrate technology into their lessons to enhance student learning outcomes in mathematics.

2. Literature Review

Technology plays a significant role in students' lives and has the potential to enhance learning, especially in challenging subjects like mathematics. However, despite its advantages, integrating technology into teaching faces barriers such as cost, accessibility, time, and lack of understanding effective teaching technology (Ajit *et al*., 2022). Often, teachers often lack confidence in delivering lessons using digital tools despite government standards for resources and documentation.

The TPACK framework provides a practical solution by employing the interplay of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) in technology adoption for teaching. This framework suggests that effective educational technology integration requires aligning content, pedagogy, and technology to enhance students' learning experiences (Mishra & Koehler, 2006).

The use of technology in teaching and learning mathematics has become a key concern for educational stakeholders and policymakers worldwide due to the student's persistently low towards the mathematics achievement (Selamat et al., 2025), the. Several factors influence its digital technology usage. The first factor is skill and prior experience in using technology for teaching. According to Muhazir and Retnawati (2020), low technology proficiency is a significant obstacle for teachers using technology in classrooms. The widespread digitalization and wide variations of digital technology facilitate teachers' critical skills and knowledge to decide on suitable times and types of digital technology for teaching (Gonscherowski & Rott, 2022). Hence, teachers must polish technology-related skills and competencies as technology evolves.

Next is the teacher's readiness to incorporate technology into teaching mathematics. They must know about integrating technology into teaching and learning. With this knowledge, the teachers should be ready and prepared for the integration. It is insufficient to provide the latest technology tools to teachers without proper knowledge and training; hence, they should be trained and equipped with relevant teaching strategies, (Spiteri & Chang Rundgren, 2020).

Finally, are the teachers' attitudes, referring to a structured psychological concept with mental-cognitive and psychological-emotional foundations and manifestations vital to their personalities, lives, and perceptions (Yavich & Davidovitch, 2021). Confidence, beliefs, self-efficacy, and relationship to school culture influence their attitudes toward digital technology implementation. The attitudes and confidence do not solely depend on its availability, as they usually utilize whatever technology is available to serve students. The key characteristics contributing to technology integration and affecting the students using it are their confidence and perception that technology is practical for learning.

Mathematics teachers face significant challenges in integrating digital technology into lessons despite its importance in enhancing teaching effectiveness. One main barrier is inadequate training and socialization, which limits their abilities to develop the necessary technology skills and familiarity with digital tools such as applications, videos, and learning websites. Training programs enhance teachers' technical capabilities and foster positive attitudes and strategic skills for effectively using technology in the classroom, thereby indirectly reducing this barrier (Muhazir & Retnawati, 2020). Another challenge is the lack of sufficient infrastructure and resources in schools. Essential facilities such as computers, projectors, and internet access are often unavailable, hindering the effective use of technology. Their adoption is constrained without adequate resources to support the implementation (Muhazir & Retnawati, 2020). Some mathematical topics are perceived as difficult to integrate with digital tools. Therefore, it is easier for teachers to teach them without technology so that students can focus directly on the specific material. These barriers underscore the need for professional development, improved infrastructure, and tailored strategies to integrate complex mathematical content with digital technology.

The integration of digital technology into classrooms has become increasingly important. Nevertheless, several variables influence its utilization by the teachers. First is gender as literature indicates that male and female teachers may engage with and respond differently to digital technology depending on social norms, self-perceived efficacy, and resource availability. Technology has always been conventionally viewed as male dominated field and this has developed into a "digital gender gap" that starts early and persists even in workplaces (Korlat *et al*., 2021). The gap is supported by stereotypes that associate technical competence with masculinity, and this can influence the confidence and preparedness of female teachers to include technology in their teaching.

An integrative study on teachers' digital competencies has extensively documented a vast gender divide. The result shows that male teachers tend to score higher in computer awareness and real practical experience with technology. It also reveals that many male teachers describe ownership of more complex and sophisticated digital competencies than female teachers (Adeoye, 2023). This type of difference affects determinants of technology use; for example, female teachers prioritize ease of use, learning time, and training more than male teachers. Therefore, female teachers could require more formal support and professional training to improve their digital literacy.

However, it is surprising to observe that several literatures fail to deny or confirm such extreme gender differences in some environments. Specifically, an evaluation of teachers' digital literacy capabilities concerning their ability to assist students with functional diversity concluded that gender is not a significant factor (Edeh *et al*., 2022). Hence, even though gender differences exist contexts or situations, such differences might not be omnipresent in nature and instead determined by other factors. Those include the learning environment, learning areas, and teachers' individual qualities and attributes.

To assist with such intricate matters in the best possible manner, it becomes ever more vital to introduce well-targeted initiatives to enhance teachers' digital capability. A good way of accomplishing this aim is to provide detailed professional development opportunities targeting pedagogical technology applications in the classroom. It empowers teachers considerably, allowing them to utilize different digital tools and resources more proficiently and confidently in teaching practices (Mcclellan, 2024). Furthermore, it is essential to establish a community of practice for teachers as such an environment enables the sharing of best practices and assists collaborative problem-solving. It, in turn, helps teachers integrate technology more easily into teaching mathematics, making learning more effective and meaningful for students (Clark-Wilson *et al*., 2020).

Piaw (2013) defines a conceptual framework as the framework of a study representing the investigation's primary variables and their relationships. The framework consists of visual or written statements depicting significant variables and their relationships. The key variables and hypothesized relationships are based on hypotheses and research evidence.

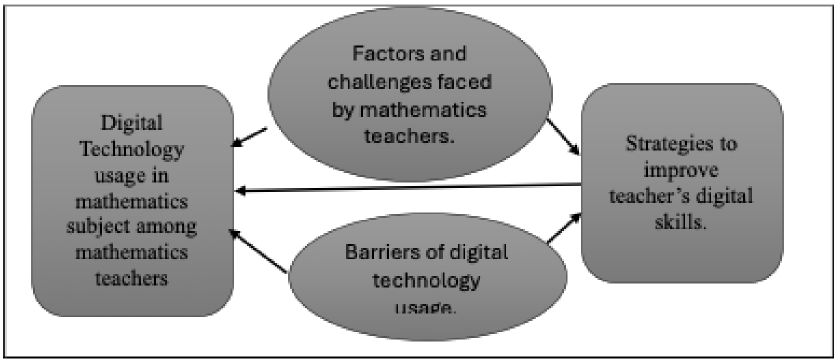

Figure 1. Conceptual frameworks of digital technology usage among mathematics teachers

Figure 1 depicts the variables observed by the researcher. The conceptual framework serves as a supporting structure developed from relevant literature. The first group of variables observed include digital technology usage among mathematics teachers, factors, and challenges faced by teachers. Meanwhile, the second group of variables are the barriers to implementing digital technology. Lastly, the third group of variables consists of strategies to improve teachers' digital skills.

3. Research Objectives

The primary purpose of this study is to determine teachers' perspectives on digital technology usage as teaching aids in the classroom. Meanwhile, the specific purposes of the study are to investigate the factors influencing digital technology usage among mathematics teachers, to identify the barriers to digital technology usage among the teachers, and to examine the strategies to improve their digital skills. Another primary purpose is to investigate the relationship between the barriers to digital technology usage among mathematics teachers and strategies to enhance their teaching skills using digital technology. More specifically, the following are research questions for the study:

a) What are the factors influencing digital technology usage among mathematics teachers?
b) What are the barriers to digital technology usage among mathematics teachers?
c) What are the strategies to improve mathematics teacher's skills using digital technology?
d) Is there any significant relationship between barriers to digital technology usage among mathematics teachers and strategies to improve their skills using digital technology?

4. Research Methodology

A quantitative approach was employed to achieve the research objectives and answer research questions of the study. According to Piaw (2013), the method emphasizes numerical data accuracy, leveraging the positivist inquiry research technique. Generally, experimental and non-experimental methods collect numerical data, which is subsequently analyzed using statistical tests.

The study employed a longitudinal design to examine variables exhibited by subjects over time. Piaw (2013) stated that longitudinal design facilitates the analysis of changes, trends, and long-term impacts, resulting in a deeper understanding of the factors, barriers, and strategies influencing mathematics teachers' digital technology usage. It involves repeated observations of the same variables, making it particularly suitable for this study.

Sampling is choosing a group from a population as research respondents (Piaw, 2013). The study applied Krejcie and Morgan (1970) table to determine the sample size for the study. With a population of 150 mathematics teachers from five different schools, the sample size of 108 is sufficient to represent a cross-section of the population. A stratified sampling technique was employed by dividing the entire population into three (3) subgroups, or strata, and then randomly selecting participants from each subgroup (Casteel & Bridier, 2021). The subgroups are the preservice, novice, and experienced teachers. The technique ensures that the sample represents each subgroup, providing greater statistical precision by reducing variability within each subgroup.

Table 1. Number of Items in Section A to D.

Section	Focus	No. of Items
A	Demographic Background	4
B	Factors contributing to digital technology usage among mathematics teachers	4
	Teachers' skills and prior experience in digital technology usage	4
	Teachers' readiness to incorporate technology into teaching mathematics	4
	Teachers' confidence, beliefs, and self-efficacy in implementing digital technology in teaching and learning	
C	Barriers to digital technology usage among mathematics teachers	8
D	Strategies to improve mathematics teacher's digital skills	8
Total		32

The questionnaire in the study serves as the primary research instrument to ensure precise and accurate results (Kubai, 2019). It was administered via both Google Forms and printed form to mathematics teachers and practicum students in five different secondary schools. It is divided into four sections, including Sections A, B, C, and D, as shown in Table 1. Whilst Section A seeks to attain demographic information of the respondents, Section B attempts to examine the factors contributing to digital technology usage among mathematic teachers. Meanwhile, Section C gauges the barriers to digital technology usage among mathematics teachers. Finally, Section D explores the strategies for improving mathematics teacher's skills using digital technology. Generally, all items except those in Section A utilize a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). They were adopted and adapted from prior studies, including Spiteri and Rundgren (2018), Muhazri and Retnawati (2020), and García *et al*. (2023), as shown in Table 2.

Table 2. Original and Revised Items Adopted and Adapted Factors Contributing to Digital Technology Usage.

Original item	**Revised items**
Teacher's skill	Skills and prior experience in digital technology usage
Teacher's knowledge	Teachers' readiness to incorporate digital technology in teaching mathematics
Teacher's attitude	Teachers' confidence, beliefs, and self-efficacy in implementing digital technology in teaching and learning
Training and introduction of software of mathematics learning are still not reaching all areas, and it is still not maximal in its implementation	Training and socialization in integrating digital technology in teaching and learning
Facilities, infrastructure, and support provided by schools are inadequate to use technology in the teaching and learning process.	Insufficient infrastructure and facilities to integrate digital technology in teaching and learning
Certain material is considered less suitable to use technological aids to focus more on the material being taught.	Integrating difficult learning materials into digital technology
Collaborating through digital technologies.	Conducting collaborative learning
Browsing, searching, and filtering data, information, and digital content	Exploring digital tools to enhance digital skills
Solving technical problems	Providing technical support to the teacher

Table 3. The Reliability of Questionnaire Items in Sections B, C and D.

Cronbach's Alpha	**N of Items**
0.803	28

Based on the SPSS output in Table 3, the overall internal consistency value or Cronbach's Alpha value for 28 items in Sections B, C, and D is 0.803. Thus, it can be concluded that the constructs in the questionnaire have a high-reliability standard. Therefore, since the value is above 0.70, none of the items need to be deleted.

5. Results and Discussions

This section presents descriptive analysis results and discussions for items from Sections A, B, C, and D. Those include the demographic background of the respondents, the factors influencing digital technology adoption among mathematics teachers, barriers to digital technology usage among the teachers, and strategies for enhancement.

5.1 Section A - Demographic Background

Table 4: Results from Section A - Demographic Background.

Gender	Male 30.6%	Female 69.4%				
Age	20-24 52.8%	25-30 6.5%	31-35 13.0%	36-40 15.7%	>50 12.0%	
Teaching Experience	<1year 52.8%	1-5 years 7.4%	5-10 years 6.5%	10-15 years 11.1%	15-20 years 9.3%	>20 years 13.0%
Level of Education	Degree 96.3%	Master 3.7%				

Table 4 presents the demographic background of the respondents. The majority are female teachers, with 69.4% (n=75), while male teachers are only 30.6% (n=33). The highest proportion of respondents is within the 20 to 24 age group with 52.7% (n = 57), followed by those in the 36 to 40 age group with 15.7% (n = 17). Next are those in the 31 to 35 age group with 13.0% (n = 14), while those in the above 50 age group are 12.0% (n = 13). Finally, the lowest is the 25 to 30 age group at 6.5% (n = 7). Generally, most respondents are between 20 and 50 years old. For teaching experience, many respondents have less than one year of teaching experience, which is 52.8% (n = 57). Followed by those with 20 years of teaching experience at 13% (n = 14), and only 6.5% (n = 7) have 5 to 10 years of teaching experience. Lastly, for education qualifications, most respondents are degree holders at 96.3% (n = 104), and only 3.7% (n = 4) possess a master's degree.

5.2 Section B - Factors influencing digital technology usage among mathematics teachers

This section describes the results for twelve (12) items in Section B to achieve research objective 1 which is to investigate the factors influencing digital technology usage among mathematics teachers.

Table 5: Results from Section B - Factors contributing to the digital technology usage among mathematics teachers.

Items	Mean	Std. Deviation
Skill and prior experience are important in the use of technology.	4.84	.391
I possess the necessary skills to effectively integrate technology into my mathematics teaching.	4.31	.880
My prior experience with technology in education positively influences my current teaching practices in mathematics.	4.31	.755
I believe that my skills in technology usage increase student engagement in mathematics lessons.	4.25	.887
Teachers need to have a readiness to incorporate technology into teaching mathematics.	4.58	.598
I believe that technology can enhance the teaching and learning of mathematics.	4.29	.854
I have received adequate training on integrating technology into mathematics instruction.	4.08	1.024
I regularly use technology in my mathematics lessons.	4.08	1.033
Teachers need to have confidence, beliefs, and self-efficacy in implementing digital technology in teaching and learning.	4.57	.583
I feel confident using digital technology in my teaching.	4.15	.955
I can effectively integrate digital tools into my lesson plans.	4.18	.984
I believe that my students benefit from the use of technology in the classroom.	4.31	.914

Table 5 tabulates the results from items in Section B and the able shows the highest agreement on the significance for skills and prior experience, with a mean of 4.84 (SD=0.391), followed by the need for readiness and preparation when incorporating technology into teaching, with a mean score of 4.58 (SD=0.598). The respondents also agreed on the need for confidence, beliefs, and self-efficacy in implementing digital technology in teaching and learning, with a mean of 4.57 (SD=0.583). They believed that prior experience with technology influences teaching practice as students benefit from it, with a mean of 4.31 (SD=0.880 and 0.914, respectively), indicating a positive attitude towards technology in the classroom. They also considered technology's ability to enhance teaching and learning processes and student engagement in mathematics lessons, with mean values of 4.29 (SD=0.854) and 4.25 (SD=0.887), respectively. They were generally confident in their ability to incorporate digital tools into lesson plans, with a mean of 4.18 (SD=0984), and effectively use digital tools, with a mean of 4.15 (SD=0.955), reflecting a good self-evaluation of their skills. However, there is some variation in areas such as adequate training, with a mean of 4.08 (SD=1.024), and frequent use of technology in mathematics lessons, with a mean of 4.08 (SD=1.033), indicating inconsistency in access to professional development opportunities and varying levels of technology integration in practice. The relatively higher standard deviations in these areas suggest a strong acknowledgment of the value and necessity of technology in mathematics teaching. It also indicates the need for more equitable access to professional development and support to ensure consistent and effective implementation.

Teachers' digital abilities have become a cornerstone of modern education, particularly in facilitating engaging learning experiences. Digital competencies are now firmly established in the canon of skills teachers should possess (Tomczyk, 2021). Digital competency is a necessary component of the skill set for current teaching professionals. In mathematics, where abstract concepts and problem-solving are usually challenging for students, digital tools can boost understanding and engagement. Its empowerment is essential for developing digitally competent teachers who can transform traditional mathematics classrooms into an online mode that is more constructive, collaborative, engaging, and supportive to the learners in a flexible and joyful learning environment (Joshi *et al*., 2023).

Furthermore, teachers who have already gained experience in digital technology applications are in a better position to incorporate these tools into their teaching. It enables teachers to manage software, choose suitable digital tools and materials, and solve technical problems. It is critical that the combination of skills and experience improves teaching efficiency and creates engaging learning environments relevant to student's interests and needs.

It underlines the need for human dedication, organizational support, and adequate training and resources. Well-equipped teachers are prone to utilize technology effectively, resulting in higher engagement and better results in mathematics teachings. Integrating technology into lessons profoundly impacts students' engagement and attitudes, which is pivotal for educational success (Hidayat & Firmanti, 2024). Training and professional development have increasingly become essential in integrating digital technology into teaching. Although numerous teachers recognize the significance of training, differences in access to these opportunities are still apparent. Those who receive extensive and specialized training are better at leveraging its benefits, which is critical for promoting consistent use. According to Haarala-Muhonen *et al.* (2023), different forms of training in digital pedagogy enhance teachers' skills and confidence in digital teaching. Therefore, it is vital that teachers should be trained on digital technology as the demand for online courses has grown, and adaptation for future society, e.g., working life, requires equipping students with digital competence (Haarala-Muhonen *et al*., 2023). However, the results of the current study show that not all teachers have equal access to such opportunities, highlighting the need for more equitable professional development programs.

Another key aspect that influences digital technology utilization among teachers is their attitudes, such as confidence, beliefs, and self-efficacy. Those are essential human factors enabling ICT integration in the classroom (Clipa *et al*., 2023). They drive teachers to use the tools more frequently, boosting teaching and learning outcomes. This optimism encourages them to invest time and effort to use technology, particularly in the face of challenges. Using interactive tools like simulations and graphing calculators, teachers may make complex subjects more approachable and encourage active participation from students.

Despite these encouraging results, the research pinpointed several areas needing enhancement. The inconsistencies in training and varying use of technology highlight the necessity for equitable access to professional development and continuous institutional backing. By tackling these challenges, teachers can fully harness digital technology's ability to enhance mathematics education, making it more engaging, efficient, and available to students. According to Geraniou and Jankvist (2019), when students engage with a digital tool to tackle a mathematical task, the interplay between their digital competencies and mathematical abilities elevates mathematical digital competency (MDC), leading to improved learning outcomes.

In today's technology-driven educational environment, teachers must be able to incorporate digital technologies into mathematics instruction. Visualizations, simulations, and interactive platforms can capture students' attention and encourage a deeper understanding of mathematical concepts. These tools make mathematics more approachable and help to close the gap between theoretical comprehension and real-world applications.

5.3 Section C - Barriers to digital technology usage among mathematics teachers

This section depicts the results for eight (8) items in Section C to accomplish research objective 2, which is to identify the barriers to digital technology usage among mathematics teachers. The integration of digital technology into mathematics teaching faces many challenges, as evidenced by the knowledge and experience of mathematics teachers. If these barriers persist, they may significantly hinder effective implementation of digital materials and their usage, potentially influencing education quality and learning outcomes.

Table 6: Results from Section C - Barriers to the digital technology usage among mathematics teachers

Items	Mean	Std. Deviation
Training and socialization for integrating digital technology in teaching and learning is important.	4.91	.291
I feel that I have not received adequate training to effectively use digital technology in my mathematics teaching.	2.75	1.033
I do not have sufficient access to digital tools and resources for teaching mathematics.	2.74	1.017
Practical examples and support from colleagues and management are important to improve digital technology skills.	4.69	.555
My school's infrastructure and facilities are insufficient to integrate the use of technology in the learning process.	4.01	.717
I feel that my school administration does not provide enough support for integrating digital technology into mathematics instruction.	4.01	.767
Difficult learning materials cannot be integrated into digital technology.	2.64	.912
Mathematics curriculum does not support the integration of digital technology.	1.74	.858

Table 6 reveals the respondents' perception of the barriers to digital technology usage among mathematics teachers. The result reveals strong agreement among respondents on the importance of training and socialization for integrating digital technology into teaching and learning, with the highest mean score of 4.91 (SD=0.291. They also valued practical examples and help from colleagues and management to improve their digital technology ability, with a mean of 4.69 (SD=0.555). Insufficient institutional assistance, and school infrastructure for technology integration were significant concerns among the respondents, with a mean of 4.01 (SD=0.717). However, the majority disagreed with the following act as the barriers to digital technology usage. First, inadequate training to effectively use digital technology in mathematics teaching, with a mean of 2.75 (SD=1.033), and second, insufficient access to digital tools and resources, with a mean of 2.74 (SD=1.017). Third is the difficulty in combining demanding learning materials with technology, with a mean of 2.64 (SD=0.912), and finally, the mathematics curriculum does not support digital technology integration, with a mean of 1.74 (SD=0.858).

One of the critical challenges is that teachers are not sufficiently trained for digital technology integration. Although there is a strong consensus concerning the need for training and socialization to bring about successful integration, many teachers consider themselves ill-prepared to employ these technologies effectively. According to Molina (2021), teacher self-efficacy is challenged as their attitudes are conflicted with integrating technology because of the lack of training received and the lack of technology skills. Current trainings do not satisfy established expectations. Response variability suggests inconsistent quality training, possibly related to differential policies, priorities, or resources by region or institution. It necessitates thorough professional development programs that impart technical skills and emphasize practical applications specific to the mathematics curriculum. Moreover, ongoing support and refresher courses are beneficial in sustaining and improving teachers' competencies over an extended period. Professional development training programs have long been recognized as catalysts for improving teaching quality and student outcomes (Shakimova *et al*., 2024).

Another major challenge relates to access and the availability of digital tools and resources. This question highlights the critical issue of resource equality. Institutions in poorly funded regions might not have the financial resources to acquire and maintain modern digital tools. Thus, instigating negative consequences for teachers and students. According to Pierce and Cleary (2024), those without Internet access, computing resources, and expertise have dramatically altered how education is delivered and have significantly highlighted the growing gaps in educational technology in academic services delivery. Meeting this goal requires the synergistic action and collaborative involvement of governmental agencies, education policymakers, and private sectors. Most importantly, equipped educational establishments with proper technological infrastructure, including hardware and software, reliable sources of internet connectivity, technical support, and regular maintenance are essential for successful digital integration into the classrooms.

Institutional support, or lack thereof, is a critical barrier. Clark-Wilson *et al*. (2020) identified obstacles to teacher use, such as a lack of time and supportive professional development, insufficient access to appropriate digital technology, and poor technical support. Many teachers believe that their school administrations are unsupportive, rating on average a score of 4.01 for both administrative encouragement and infrastructure provision. Several barriers hinder effective technology integration in teaching-learning practices, including lack of resources, leadership support, accessibility of ICT infrastructure, inadequate time, unclear policies, professional development, technical support, and lack of appropriate pedagogical models (Akram *et al*., 2022). Without the perception underlining the need for system-level solutions, effective technology integration cannot transpire. A whole-school environment should have a collaborative, innovative, and autonomous spirit, where school leaders nurture an environment that supports technology integration through effective strategic planning, resource allocation, and policy implementation. Furthermore, providing channels for peer support and mentoring might help educators collectively overcome barriers and develop their confidence and effectiveness in using digital tools.

Curricular constraints severely exacerbate the problem at hand. Teachers cannot integrate digital resources with complex learning materials. Insufficiency of in-service and pre-service training, content support, and incentive systems emerged as major perceived obstacles to technology integration (Atabek, 2019). In addition, the mathematics curriculum is viewed as less supportive of incorporating digital technology, The previous argument is evidence of the great chasm between curriculum development and the potential of digital technology. It remains paramount that curriculum developers collaborate with both teachers and technology experts to create learning outcomes and resources that effectively incorporate technology. In so doing, the collaboration focuses on creating interactive content, developing assessment strategies based on technology, and including digital literacy across the curriculum for both teachers and students.

As it is, the barriers to digital technology integration into mathematics education are multidimensional and require comprehensive approaches to their solution. Overcoming them need strong training programs, equal access to resources, significant institutional support, and curriculum changes. With such investment in education systems, teachers in classrooms should be empowered to make confident and creative use of digital tools, improving the way of teaching and learning. This transformation requires a commitment at all levels, from individual educators to policymakers, to ensure that technology facilitates success in mathematics education instead of as a barrier.

5.4 Section D - Strategies to improve mathematics teacher's digital skills

This section describes the results for eight (8) items in Section D to achieve research objective 3 which is to examine the strategies to improve mathematics teachers' digital skills.

Table 7: Results from Section D - Strategies to improve mathematics teacher's digital skills.

Items	Mean	Std. Deviation
Doing collaborative learning.	4.90	.304
Collaborating with colleagues to share digital teaching strategies enhances my digital skills in mathematics education.	4.92	.278
Networking with other educators who are experienced in digital technology enhances my knowledge and skills in teaching mathematics.	4.93	.297
Exploring digital tools can enhance my digital skills.	4.92	.278
Having access to online resources and tutorials supports my development of digital skills for teaching mathematics.	4.93	.263
School should provide technical support to the teachers.	4.94	.230
Opportunities to implement new digital tools in a supportive classroom environment enhance my confidence and skills.	4.91	.322
Regularly scheduled training sessions on new digital tools and technologies are essential for my growth as a mathematics teacher.	4.94	.247

Table 7 depicts the results from items in Section D, and the table shows the mean values range between 4.90 to 4.94 and standard deviation values range between 0.247 to 0.322. The highest mean value is 4.94 (SD=0.230 and 0.247, respectively) for "School should provide technical support to teachers" and "Regularly scheduled training sessions on new digital tools and technologies are essential for my growth as a mathematics teacher". Next, the value of 4.93 (SD=0.297 and 0.263, respectively) is for "Networking with other educators who are experienced in digital technology enhances my knowledge and skills in teaching mathematics" and "Having access to online resources and tutorials supports my development of digital skills for teaching mathematics". The results reflect the perceived importance of knowledge sharing and the use of digital tools to improve teaching abilities. This is followed by the mean value of 4.92 (SD=0.276 and 0.263, respectively) for "Collaborating with colleagues to share digital teaching strategies enhances my digital skills in mathematics education" and "Exploring digital tools can enhance my digital skills". Meanwhile, the mean value for "Opportunities to implement new digital tools in a supportive classroom environment enhance my confidence and skills" is 4.91 (SD=0.322). Finally, the lowest mean value is for "Doing collaborative learning", with 4.90 (SD=.0.304), emphasizing the importance of teamwork in professional development.

Digital technology is vital in today's rapidly changing educational environment to develop good instructional practices and learning experiences. The subject of mathematics has benefited from advanced technology in the dynamic and innovative practices that can now be utilized in teaching. For this potential to be fully realized, mathematics teachers need the competence and confidence to work effectively with technology in their classrooms. The study under discussion identifies the strategies for achieving this, such as collaborations, self-exploring access to resources and digital tools, and institutional support. Together, they give a complete framework for professional development, preparing teachers to meet challenges in the modern educational landscape.

According to Pozas and Letzel-Alt (2023), collaboration among teachers can play a meaningful role in teachers' instructional behavior. Collaborative efforts among teachers and networking with more experienced teachers are instrumental means of professional development, as shown in the results. Within the school context, collaboration can mean that two or more teachers work with other pedagogical specialists to design inclusive learning environments and support students in their personal and social development (Pozas & Letzel-Alt, 2023). They offer great opportunities for sharing the best practices and common challenges, besides building mutual support. It enriches teacher's expertise and collective knowledge within the teaching community. Creating a professional learning community and educator network allows schools to provide platforms where teachers can get involved in constant dialogue and collaboration.

The results also underline the importance of self-directed learning in professional development. The strategy significantly predicts blended cooperative learning satisfaction, and the action path can be summarized as "goal-driven, resource-promoting, evaluation-guaranteeing, and strategy-first" (Hua *et al*., 2024). This way, teachers can tailor learning to their needs and teaching contexts. The availability of better online resources gives teachers the needed flexibility for professional development to catch up with new technologies. Schools could support this autonomy by providing teachers access to approved digital libraries, lesson plans, and professional growth models to explore and learn at their own pace.

Institutional support, such as technical support and regular schedule training, is fundamental to improving teachers' digital competencies. The results highlight the critical role of schools in creating an enabling environment for digital skill development. Technical support empowers teachers to overcome challenges and confidently adjust to new technological tools. Schools are also responsible for providing regular training programs to teachers so that they can always keep abreast of advancing technology. These elements create a continuous learning culture and innovation, allowing teachers to integrate digital resources seamlessly into teaching practices.

5.5 Relationship between barriers to digital technology usage among mathematics teachers and strategies to improve digital technology skills

Table 8 below shows the results from the inferential analysis conducted to determine the significant relationship between barriers to the digital technology usage among mathematics teachers and strategies to improve their digital technology skills.

H_0: The barriers to digital technology usage among mathematics teachers and the strategies for improving their skills using digital technology are independent.

H_1: The barriers to digital technology usage among mathematics teachers and the strategies for improving their skills using digital technology are related.

Table 8: The results from inferential statistics to test the hypotheses.

			Barriers	Strategies
Spearman's rho	Barriers	Correlation Coefficient	1.000	-.219*
		Sig. (2-tailed)	.	.023
		N	108	108
	Strategies	Correlation Coefficient	-.219*	1.000
		Sig. (2-tailed)	.023	.
		N	108	108
*. Correlation is significant at the 0.05 level (2-tailed).				

Since the p-value is less than 0.05, so H_0 is rejected. A Spearman's rho correlation results indicate that the relationship between the barriers and the strategies is statistically significant (r = -0.219, p = 0.023). The discovered negative connection shows that when barriers to digital technology usage are reduced, the effectiveness or implementation of measures for teacher competency development improves. On the other hand, high barriers may hinder the effectiveness of strategies meant to foster digital technology integration. This calls for great concern in addressing the obstacles, such as inadequate training, lack of access to technology, and resistance to change, since they directly impact the success of improvement strategies.

Meanwhile, Spearman's rho correlation test reveals a statistically significant negative correlation (r = −0.219, p = 0.023) for H_0. This finding suggests that the barriers and strategies are interconnected. Specifically, as the barriers diminish, the effectiveness of strategies for improving teachers' digital competency increases. In contrast, the barriers can obstruct the successful implementation of these strategies. Consequently, the null hypothesis H_0, which asserts that the barriers and strategies are independent, is rejected.

The inverse relationship indicates that tackling the barriers is essential for successful improvement strategies. Factors such as insufficient training, limited access to technology, and resistance to change significantly influence teachers' ability to adopt and integrate digital tools into their teaching practices. For example, even when development policies are in place, however, due to lack of adequate training, teachers feel unprepared or have limited knowledge to utilize digital technology commendably. Similarly, unequal opportunities in digital access further restrict skills enhancement opportunities, which widen the gap between policy goals and real results. Even though many teachers acknowledge the benefits of technology in education, many are concerned about sufficient technological infrastructure in schools (Zengin, 2023). Therefore, these external and internal challenges must be addressed to ascertain the triumphant implementation.

It is imperative to provide specific recommendations to overcome these challenges. First, professional development programs should be carried out to cater to the unique requirements of mathematics teachers. The programs must prioritize technical skills and teaching techniques for digital tools usage in mathematics education. Second, infrastructure improvement should be invested to guarantee equal access to essential digital tools and dependable internet connectivity. Such investments would empower schools in disadvantaged areas to break through systemic obstacles to technology adoption.

Furthermore, it is essential to prioritize efforts to reduce resistance to change. Clear communication of digital technology merits and ongoing support mechanisms assist teachers in navigating the transition and building confidence in using new tools. Establishing regular feedback mechanisms can further ensure that the strategies are responsive to educators' evolving needs and provide real-time solutions to emerging challenges.

The findings highlight the need to mitigate drawbacks in reaping the strategies benefits to enhance digital technology usage among mathematics teachers. By comprehensively navigating these conundrums, stakeholders can elevate the overall success of skill development programs. It will lead to a more impactful digital technology adoption in mathematics education. Such initiatives are pivotal for equipping teachers to meet the challenges of 21st-century teaching and creating a learning environment rich in technology.

6. Conclusion

Overall, the study highlights the factors, barriers, and strategies affecting digital technology in effective mathematics teaching and learning. Technological platforms, when used correctly, boost interaction and create more meaningful learning. On the contrary, improper application causes issues like insufficient training, lack of resources, and poor infrastructure to impede the intended outcomes. Therefore, the study stresses preparing teachers with digital technology skills via constant training provision for professional and skills development. However, such training should be explicitly designed to accommodate the specific needs of mathematics teachers, focusing on the latest developments in innovation and current uses.

The study also emphasizes the necessity of readily available text, software, and media supporting mathematics teaching purposes. The schools should ensure focused technical support and opportunities are obtainable for knowledge and best practices exchange among the teachers. By resolving these challenges, a conducive environment that enables teachers to integrate technology into their curriculum and instructional practices more seamlessly.

Finally, these strategies benefit teachers and contribute positively to students' learning. Teachers can develop more engaging and student centered approaches to teaching using technology integrated into teaching practice. It establishes a basis for coherent learning processes, contributing to improved comprehension of intricate subjects such as mathematics. Specifically, this strategy improves students' performance and prepares them for a future that depends on digital literacy. The operational policies, school executives, and professional development conveners should work with policymakers to bring technology into education so that students and teachers can access and gain from the opportunities come with technology applications.

Acknowledgement

The authors extend their heartfelt gratitude to the reviewers for their invaluable and insightful suggestions.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contribution

Mhd Pizor, A. A. conceived and planned the experiments and carried out the experiments and carried out the simulations. Othman, Z. S. contributed to the interpretation of the results and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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