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UTILIZING MATHEMATICAL SOFTWARE FOR THE TEACHING AND LEARNING OF MATHEMATICS IN MALAYSIA

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ABSTRACT

The paper examines the effects of mathematical software on the academic performance of secondary school students, along with its roles in facilitating technological adaptation among the students in mathematics education. The study is motivated by persistent challenges in students' mathematics achievement and the limited integration of technology in classroom practices, despite the increasing availability of digital tools in schools. Two main objectives guided the research are to evaluate the effectiveness of mathematical software in improving students' comprehension of mathematics, and to measure the extent of technology integration among students in mathematics learning. A quantitative research design was employed, involving 100 student respondents from Sekolah Menengah Kebangsaan Meru, Klang. Data were collected through questionnaires administered via Google Forms after obtaining the necessary approvals. The findings reveal that students using mathematical software reported a 22% improvement in their comprehension levels, along with enhanced flexibility, critical thinking, learning interest, and classroom interactivity. These results underscore the potential of mathematical software not only to strengthen students' academic performance but also to build their readiness to embrace technology in learning mathematics. The study highlights the importance for educators and policymakers to integrate mathematical software more systematically into pedagogical practices to maximize its educational benefits.

Keywords*: Mathematics Education, Mathematical Software, Students' Performance in Mathematics, Technology Adaptation.*

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1. Introduction

The application of mathematical software in mathematics education is a matter of considerable relevance and importance. Incorporation of technological tools, here in the form of mathematical software packages, has been found to have a positive effect on the learning and achievements of students. Academic research has emphasized the advantages of employing mathematical software for teaching mathematics, especially for facilitating the performance and interest of students in mathematics. Literature has demonstrated that the utilization of mathematical software like Mathematica and GeoGebra has the potential to stimulate student engagement, raise the level of education, and promote the comprehension of students regarding mathematical concepts (Bakar *et al.*, 2015; Xu & Chen, 2022; Li *et al.*, 2022). The utilization of dynamic software like Autograph and Hawgent is effective in facilitating mathematical problem-solving skills and promoting various representations of mathematics, thereby making the learning experiences of students more enriching (Wijaya *et al.*, 2020).

The significance of cooperation between software designers and educators has been highlighted as essential in the development of helpful software tools that are aligned with learning goals and facilitate the teaching and learning of mathematics (Ince-Muslu & Erduran, 2020). Educational software has played an important role in enhancing the learning process and engaging learners in the field of mathematics education (Cao *et al.*, 2022; Paulo *et al.*, 2022). Besides that, the application of mathematics software has been associated with better academic performance in mathematics, as research indicates beneficial influences on the performance and comprehension of mathematical concepts among students (Li et al., 2022; Karim & Falahi, 2018; Fatemi *et al.*, 2012). The use of computer-mediated instructional strategies and interactive mathematics software has been shown to facilitate students' skills in mathematical problem-solving and improve their learning outcomes (Hamadneh *et al.*, 2016; Barba-Guaman & Valdiviezo-Diaz, 2017).

1.1 Background of Study

Mathematical software applications in teaching and learning mathematics have shown a positive impact in enhancing students' skills and performance. For instance, Tan *et al.* (2020) reported improvements in students' creative thinking when problem-based learning strategies were combined with dynamic mathematics software. Similarly, Wijaya *et al.* (2021) focused on developing students' trigonometry competencies alongside the creative thinking skills of prospective mathematics teachers through the use of dynamic mathematics software.

The integration of technological tools such as GeoGebra has also gained significant attention in research. Iparraguirre-Villanueva (2024) explored the use of GeoGebra Calculator 3D with augmented reality to create interactive and immersive mathematical learning experiences. Likewise, Yerizon *et al.* (2021) demonstrated how GeoGebra can improve students' spatial abilities, further highlighting the potential of such tools to enhance mathematical learning outcomes.

Beyond software-specific studies, broader research has examined how technology influences mathematics education. Bright (2024) emphasized the importance of student engagement in mediating mathematics achievement, while Musiimenta *et al.* (2019) highlighted how electronic learning can improve mathematics teaching and learning, particularly in disadvantaged school settings.

Overall, the body of literature indicates that the use of mathematical software positively impacts students' learning outcomes by enhancing creative thinking, strengthening conceptual understanding, and improving motivation. These findings underscore the value of leveraging technology to enrich mathematics learning experiences, especially within the context of secondary education in Malaysia.

In conclusion, the research literature supports the idea that incorporating mathematical software in teaching mathematics can lead to improved student outcomes, including enhanced creative thinking abilities, better understanding of mathematical concepts, and increased student engagement. These findings underscore the importance of leveraging technology to enrich the teaching and learning experience in mathematics education, particularly in the context of secondary school students in Malaysia. (Hamadneh *et al.,* 2016; Barba-Guaman & Valdiviezo-Diaz, 2017).

1.2 Statement of Problem

At the secondary school level, many students struggle to perform well in mathematics because they often rely on memorizing formulas without fully understanding the underlying concepts. This lack of conceptual understanding, particularly in topics such as geometry, stems in part from the difficulty teachers face in providing clear visual explanations of mathematical principles. As a result, students become confused during examinations, lose interest, and develop negative attitudes toward Mathematics (Benta, 2024).

Creating a supportive learning environment is essential, as prior studies have shown that motivation, engagement, and a sense of belonging significantly influence students' achievement in Mathematics (Maqoqa, 2024; Armah & Kissi, 2019). However, even when students display positive attitudes and motivation toward the subject, these factors alone do not necessarily guarantee improved academic performance (Selamat *et al.*, 2025). In many classrooms, traditional teacher-centered methods dominate, offering limited opportunities for active, technology-enhanced, or interactive learning. This gap highlights the need for innovative teaching approaches that move beyond rote memorization and foster deeper comprehension.

To combat these issues, a variety of strategies and tools have been suggested. For instance, the use of blended learning through PhET simulations and instructional materials has been suggested for enhancing students' conceptual understanding (Schmid, 2023). Additionally, the use of tools like GeoGebra for geometry visualization through Virtual Reality (VR) and Augmented Reality (AR) applications can be employed to improve students' spatial reasoning abilities, bridging the gap between 2D representations and 3D mental models (Sogen, 2023). Integration of cultural arts activities in schools, including music, visual arts, and dance, can help promote creativity among teaching and learning, thus an integrated approach to student engagement (Magfiroh, 2024). Further integration of innovative strategies, such as the snowball-throwing model of cooperative learning, can help improve students' communication skills and concept comprehension, away from the conventional teacher-centered approaches (Fajari, 2020). Addressing this problem is critical to improving not only students' academic performance but also their long-term engagement and confidence in mathematics.

1.3 Research Objective

This research is conducted to study the students' perception of learning mathematics with the aid of mathematical software by addressing the following objectives:

i. To evaluate the effectiveness of mathematical software in improving students' comprehension of mathematics.

ii. To measure the extent of technology integration among students in mathematics learning.

2. Literature Review

2.1 Learning Using the Hybrid Method Compared to the Conventional Method

The idea of hybrid learning, in which traditional face-to-face instruction is mixed with digital technology, has garnered significant attention in educational studies. Empirical findings have demonstrated that hybrid modes of teaching can enhance learning outcomes, more actively engage students, and lead to better academic performances than traditional modes of teaching (Kurniawan *et al.,* 2022; Lestari *et al.,* 2022; Paramitha *et al.,* 2021; Aristika *et al.,* 2021; Listiana, 2022).

One of the key advantages of hybrid learning is that it can cater to different learning styles and each learner's individual needs, thus offering a more personalized learning experience (Rahmawati *et al.,* 2022). The combination of conventional and digital learning approaches in hybrid education offers the potential for learners to choose materials and techniques aligned with their individual interests and learning objectives, thereby supporting greater engagement and motivation (Yousry & Azab, 2022).

Besides, hybrid learning has been shown to promote collaborative learning spaces through enabling group projects and discussions, thereby enhancing student solidarity and collaboration. Hybrid learning's collaborative nature can promote students' social interactions and communication skills, making the learning process more interactive and engaging (Chang *et al.,* 2020).

Furthermore, the integration of technology into hybrid learning paradigms, as exemplified by the utilization of deep learning algorithms and computer-assisted diagnostic systems, has demonstrated encouraging prospects in various fields, such as dentistry and medicine (Mankutė *et al.,* 2022). The utilization of these sorts of technological innovations within hybrid learning contexts has the potential to enhance the effectiveness and accuracy of tasks such as automated diagnosis and learning abilities, thereby unveiling new possibilities for education.

2.2 Effectiveness of Mathematics Software in Learning Mathematics

The use of mathematics software to support mathematics education has become an active area of research in the field of education. Several studies have found the beneficial influence of dynamic mathematics software on teaching practices. For instance, research findings indicate that the use of GeoGebra software can enhance the mathematical skills of students (Juandi *et al.,* 2021). Similarly, the application of Hawgent dynamic mathematics software has been positively rated by both students and teachers as its potential to serve as an educational tool (Pereira *et al.,* 2021). Moreover, studies have indicated that educational software plays a significant role in bridging the gap between mathematical theory and practice in the learning setting (Paulo *et al.,* 2022). Furthermore, technology use, particularly dynamic mathematics software, has been shown to enhance the creative thinking capacity of mathematics students and educators (Wijaya *et al.,* 2021).

It has been observed by researchers that the advantages that come with the utilization of Information and Communication Technologies (ICT) in teaching mathematics, particularly its role in enhancing students' academic performance (Onoshakpokaiye, 2023). Moreover, computer software like Mathematica has been researched to enhance the effectiveness of teaching approaches in mathematics on a daily basis (Xu & Chen, 2022). In addition, motivation-related factors such as expectancy, value, and social support have been found to significantly influence learners' engagement with technology-supported learning environments in higher education (Izni *et al.*, 2024).

2.3 Adaptation Level of Using Technologies Among Secondary Students

Technological integration within education has evolved significantly, particularly in trying to advance learning opportunities and the academic performance of students. Studies demonstrate a modest rate of acceptance and use of wearable technology by students in different fields of study, including Human Medicine (Yllaconza, 2024). The inclusion of technology is not just evident in specialist subjects but is part of a more general trend being reported across all education levels, even at the secondary education level.

Following the COVID-19 pandemic, there has been a massive increase in the utilization of education technology solutions, with the demand for e-learning and the adoption of digital materials (Teräs *et al.,* 2020). The shift to technology integration in education is not just a response to externalities, like the pandemic, but also because schools and universities have long wanted to incorporate technology for the aim of achieving better education equity (Bingham, 2021). One should understand how technology may be effectively integrated within classrooms to be able to guarantee that learners are benefiting from these innovations.

In addition, the use of technology in secondary education encompasses not only wearable technology but also a broad range of tools that range from art therapy to information and communication technology (ICT) (Mittal *et al.,* 2022). Secondary schools are tasked with preparing students for success in a technologically rapidly changing world, and as such, science, technology, engineering, and mathematics (STEM) education is a priority (Khan, 2024). By adopting STEM education, the schools can empower students with the necessary skills to navigate a technology-heavy world. Adoption of technology by education is more about how to integrate it with instructional practices and not just about the technology alone. Distributed leadership has been advocated as a school-level facilitator of technology integration in schools, as it emphasizes practices at the school level in leveraging meaningful use of technology in classes (Bingham, 2021).

Besides, integrating technology-supported project-based learning with digital storytelling has also been shown to enhance students' learning experiences and digital literacy skills (Kim *et al.,* 2021). The continual evolution in technology has given rise to an emergent interest in the utilization of artificial intelligence and wearable sensors with the aim of optimizing learning outcomes in institutions of higher education (Khosravi *et al.,* 2022; Ramalingam, 2024). Technologies like these are not only leveraged to individualize learning experience according to the needs of a person but also to optimize learning spaces' inclusivity and functionality for learners (Ramalingam, 2024).

Additionally, the combination of conventional instructional methods and contemporary technology strategies has been shown to improve the skills and productivity of students in technology-enabled classrooms (Noursi, 2020).

3. Methodology

The study employs quantitative research methods to assess the impact of using mathematical software on the learning process. It involved two groups of students, with the participants not being randomly assigned. As a result, the two groups did not share similar characteristics. Both groups completed questionnaires and tests, with one group having prior experience with learning through mathematical software, and the other group using conventional teaching methods. The research was conducted over one month, and the student's achievement was determined by the group with the highest total test score. This study has been approved by the UiTM Research Ethics Committee (ED/REC/F/103330).

A purposive sample of 100 participants from SMK Meru, Klang, responded to the survey. To fulfil the research objectives, the researcher designed a questionnaire consisting of two sections: demographics and research-related questions. The instrument used is a 5-point Likert-scale survey with 3 sections. Section A has items on the demographic profile. Section B has 10 items on students' perception of mathematical software, and Section C has 9 multiple-choice questions with 1 mark each under the topic of Polygon to investigate the effectiveness of using mathematical software in learning mathematics among the students.

The second set of data that was examined, based on Section B, pertained to the students' academic performance and the methods they used for learning. An independent t-test was employed to determine whether the utilization of mathematical software as an educational tool could enhance learning outcomes in the Polygon topic. Additionally, the independent t-test was employed to compare the means between two distinct groups. By examining the results of the independent t-test, the researchers could assess the significance of the difference between students' learning methods and their performance in the conducted test. For the significance value, < 0.05 means there is a significant difference, while > 0.05 means there is no significant difference. Furthermore, a chi-square test was employed to illustrate the relationship between respondents' learning methods (conventional and hybrid approaches) and their scores.

4. Findings

4.1 Findings for Demographic Profile

Among the respondents, there are 59 (59.0%) females and 41 (41.0%) males, making a total of 100 participants in this research study.

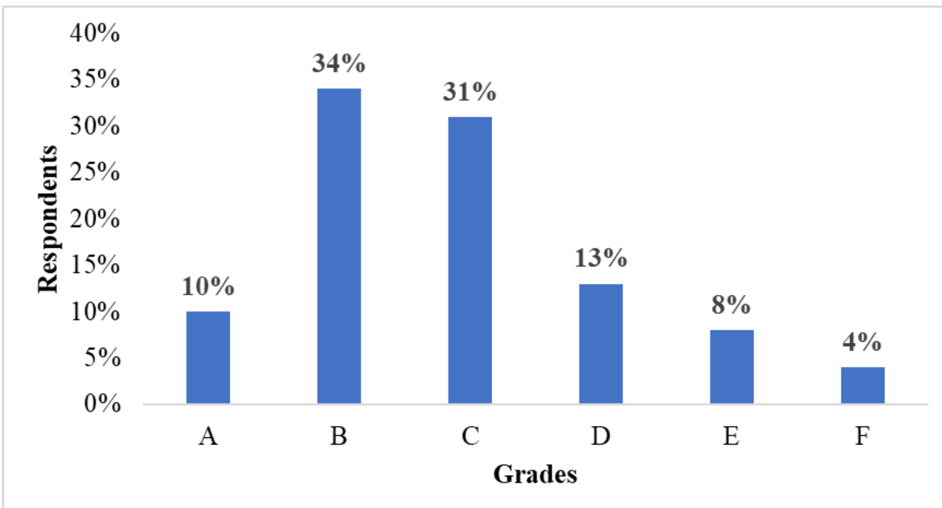

Figure 1. Percentage for Gender.

Figure 1 displays the breakdown of final year examination grades in 2022, including A (85 – 100), B (70 – 84), C (60 – 69), D (50 – 59), E (40 – 49), and F (0 – 39). Among the respondents, 10 (10.0%) received an A, 34 (34.0%) received a B, 31 (31.0%) received a C, 13 (13.0%) received a D, 8 (8.0%) received an E, and 4 (4.0%) students obtained an F as their final year examination results in 2022.

The researchers categorize learning methods into two groups: the conventional approach, where the teaching and learning process is conducted by using a whiteboard, marker, mahjong paper, and manilla card only, and the hybrid approach where the conventional approach is combined with the use of mathematics software such as GeoGebra, Maple, and MATLAB. The results show that the learning methods adopted by the respondents for the mathematics subject, with 51 (51.0%) respondents opting for the conventional method, while 49 (49.0%) chose the hybrid approach.

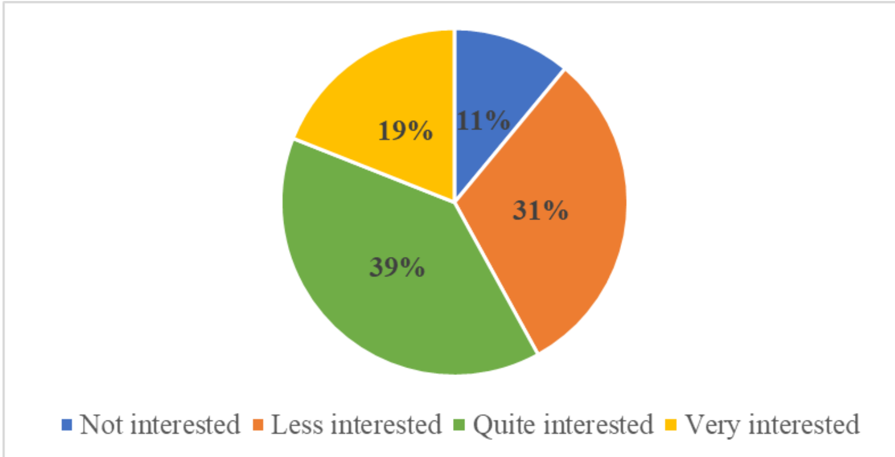

Figure 2. Percentage of Respondents' Interest in Mathematics

In Figure 2, the respondents' level of interest in mathematics is illustrated. Among the respondents, 11 (11.0%) do not find mathematics interesting, while 31 (31.0%) consider it less interesting. Additionally, 39 (39.0%) respondents find mathematics quite interesting, and 19 (19.0%) regard it as very interesting.

4.2 Findings for Research Questions

This section will delve into the research findings obtained through the data collected from the respondents to address the research questions proposed.

4.2.1 What is Mathematic Software's effectiveness level in helping secondary school students in Mathematics?

The hypothesis to be considered for this research question is

H_0: There is no relationship between the implementation of mathematical software and students' scores.

H_1: There is a relationship between the implementation of mathematical software and students' scores.

The first research question aims to identify the effectiveness level of mathematical software in facilitating the learning of mathematics for secondary school students. A descriptive analysis was carried out on three items of the software's effectiveness.

Table 1. Descriptive Analysis of Mathematical Software Effectiveness in Learning Mathematics.

Items	N	Mean	Std. Deviation
Software Mathematic can enhance my understanding in Mathematics subject.	100	3.34	1.148
Mathematic software can make the learning become more interesting.	100	3.58	1.191
Leaning Mathematics become much easier if using Mathematic software.	100	3.34	1.281
Valid N (listwise)	100		

Based on Table 1, it is evident that students perceive mathematics as more engaging when mathematical software is incorporated into their lessons, with the mean obtained being 3.58, and the SD being 1.191. On average, they find mathematics significantly more manageable when utilizing mathematical software (mean = 3.34, SD = 1.281). The item receiving a similar rating from students was "Software Mathematic can enhance my understanding of the mathematics subject" with a mean of 3.34 and the SD of 1.148.

Table 2. Descriptive Analysis of Polygon Topic Proficiency Test.

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Score	100	9	0	9	4.80	2.570
Valid N (listwise)	100					

The respondents underwent an assessment to evaluate their proficiency in the Polygon topic, which pertains to geometry. The descriptive analysis presented in Table 2 reveals that, on average, the respondents demonstrated a moderate level of performance on the test (mean = 4.80, SD = 2.570). The lowest-scoring student obtained a score of 0, while the highest-scoring student achieved a score of 9, resulting in a range of 9 points between the lowest and highest test scores.

Table 3. Group Statistics of Grades by Learning Method.

	Learning Method	N	Mean	Std. Deviation	Std. Error Mean
Grade	Conventional way (using whiteboard, marker, mahjong, paper and manilla card only)	51	3.22	1.316	.184
	Hybrid way (using whiteboard, marker, mahjong, paper, manilla card and Mathematic software such as GeoGebra, Maple and MATLAB	49	2.51	1.063	.152

Referring to Table 3, the question of the existence of a significant difference in grades between respondents who follow a conventional learning approach and those who embrace a hybrid method is addressed. The results indicate a notable difference in grades between students who followed the conventional learning approach and those who participated in a hybrid learning method. Specifically, the conventional learning group achieved a higher mean grade of 3.22 (SD = 1.316) compared to the hybrid learning group with a lower mean grade of 2.51 (SD = 1.063). The standard error of the mean is relatively small for both groups (0.184 for conventional, 0.152 for hybrid), suggesting that the sample means are reliable representations of the respective populations. Thus, an independent samples t-test was performed, and the outcome is displayed in Table 4.

Table 4. Independent t-Test of Grades between Conventional and Hybrid Learning Methods.

		Levene's Tests for Equality of Variance					t-test for Equality of Means		95% Confidence interval of the Difference	
		F	Sig.	t	df	Sig (2-tailed	Mean Difference	Std. Error Difference	Lower	Upper
Grade	Equal variances assumed	1.329	.252	2.942	98	.004	.705	.240	.230	1.181
	Equal variances not assumed			2.954	95.219	.004	.705	.239	.231	1.180

The analysis yielded a t-value of 2.942, with df is 98, and a Sig. of 0.04. These findings imply a significant difference in grades between the two groups. Specifically, respondents following the conventional approach achieved significantly lower grades compared to those adopting the hybrid method, as indicated by the higher mean, which suggests that a greater number of respondents earned lower grades.

Table 5. Chi-Square Test for the Relationship between Learning Approaches and Geometry Test Performance.

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	28.56[a]	9	.001
Likelihood Ratio	33.957	9	.000
Linear-by-Linear Association	19.543	1	.000
N of Valid Cases	100		

a. 9 cells(45.0% have expected count less than 5. The minimum expected count is 1.96.

Given that the p-value is below 0.05, we can confidently reject the null hypothesis (H_0). An examination of the relationship between the respondents' learning methods (conventional and hybrid approaches) and their scores was carried out using a Chi-square test of independence. The analysis revealed a statistically significant relationship between these variables, with a Chi-square value of 28.456, df of 9, and a sig. of 0.001. This suggests a meaningful association between the learning methods and performance in the geometry test, with significantly different score distributions observed between the hybrid and conventional approaches.

4.2.2 What is the effectiveness level of mathematical software in helping secondary school students with mathematics?

For the second research question, the following set of hypotheses is to be considered for this research question as follows.
H_0: There is no relationship between the adaptation level of technologies in mathematics and student achievement.
H_1: There is a relationship between the adaptation level of technologies in mathematics and students' achievement.

Table 6. Descriptive Statistics of Students' Technology Adaptation in Learning Mathematics.

Research Question	**N**	**Mean**	**Std. Deviation**
I already know about Mathematics software such as GeoGebra, Mape and MATLAB before.	100	3.33	1.190
I have good experience in learning Mathematics by using Mathematic Software.	100	3.05	1.540
I would like to learn Mathematics by using Mathematics software in future.	100	3.38	1.245
I do not have problem to learn Mathematics by using Mathematic software.	100	3,29	1.183
I would like to know more detail about Mathematic software.	100	3.36	1.299
I prefer to learn by using Mathematic software rather than using whiteboard only.	100	3.49	1.360
I can adopt well in learning Mathematics using Mathematics software.	100	3.30	1.299
Valid N (listwise)	100		

The second research question aims to assess the level of technology adaptation among secondary school students in the context of mathematics. Descriptive analysis was performed on the respondents' responses to seven items measuring their adaptability. As shown in Table 6, the respondents exhibit a preference for learning with mathematical software as opposed to solely using a whiteboard (mean = 3.49, SD = 1.360). On average, they express a desire to learn mathematics using mathematical software in the future (mean = 3.38, SD = 1.245), a keen interest in gaining more knowledge about mathematical software (mean = 3.36, SD = 1.299), prior familiarity with mathematical software such as GeoGebra, Maple, and MATLAB (mean = 3.33, SD = 1.190), a good ability to adapt to learning mathematics with mathematical software (mean = 3.30, SD = 1.299), and minimal difficulties when learning mathematics with mathematical software (mean = 3.29, SD = 1.183).

The lowest rating provided by the respondents was for the item "I have good experience in learning mathematics by using mathematical software," with a mean of 3.05 and an SD of 1.540. This outcome suggests that students have a preference for learning mathematics using mathematical software over conventional approaches. Additionally, all the items within this variable indicate that the respondents exhibit a strong ability to adapt effectively to learning through the use of mathematical software.

5. Conclusion

This study identifies the noteworthy influence of mathematical software on the secondary school students' learning process, particularly in their adjustment to technological support in mathematics education. The results indicate that students perceive mathematics as more interesting and comprehensible when they use software packages, which enhances the speed and ease of grasping mathematical ideas. Findings of this study align with the research by Rosni *et al.* (2024), which studied the effectiveness of educational games in mathematics that yield positive effects in students' performance and are able to promote students' interest. The beneficial effects associated with the application of mathematical software are reflected in the enhanced performance of students after a hybrid learning process, as opposed to students who adhere to conventional methods of instruction.

The study also brings to light the ability of students to adapt to technological tools in their mathematics learning. Students expressed a preference for using mathematics software, which shows an openness to embracing digital tools to enhance their learning experiences. This adaptability demonstrates that the use of technology in learning environments can create a more stimulating and effective learning environment.

This study encourages educators to employ innovative teaching practices that integrate technology, thereby enhancing student engagement and comprehension. Besides, professional development workshops and focused training can empower teachers with the needed proficiency required for proficient use of mathematics software, thus leading to enhanced learning outcomes. Furthermore, the findings of this research imply that governments and educational institutions should invest in the acquisition and maintenance of mathematical software and the required infrastructure to facilitate its adoption. This will make it possible for all students to be exposed to useful technological tools, thereby improving their performance.

These findings should be considered by policymakers within the Ministry of Education when forming technology integration strategies for mathematics education. Deeper understanding of the impact of technological integration on existing teachers, ushering in an era of technological education should be taken into consideration by these stakeholders (Johari *et al.*, 2024). Investing in technology infrastructure, giving guidelines on software selection, and providing professional development for teachers can greatly impact the quality of mathematics education.

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Author Contribution

Naiim Fatimi Che Mansor conducted the literature review, collected the data, and contributed to the initial draft writing. Saufianim Jana Aksah, as the corresponding author, supervised the project, guided the research process, and reviewed the manuscript for content accuracy. Nor Aziyatul Izni performed the data analysis and contributed to the interpretation of the results. Khairul Huda Yusof contributed to the methodology design and critically reviewed and revised the manuscript. M. N. Mohammed provided input on the conceptual framework, ensured consistency in formatting and structure, and assisted in the final proofreading. All authors read and approved the final manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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