

Assessing the role of online mathematics tools in enhancing student learning and engagement

Olajumoke Olayemi Salami, Erica Dorethea Spangenberg

Department of Mathematics, Science and Technology Education, University of Johannesburg,
PO Box 524, Auckland Park, 2006, South Africa

Abstract. As digital technology improves and educational standards rise, online tools for teaching mathematics are one of the advancements recorded in digital technologies. The use of digital tools for teaching, particularly a dreaded subject like mathematics, helps to improve teaching and learning. This study explores the influence of online learning tools on the teaching of mathematics in the era of the Fourth Industrial Revolution (4IR), where the fusion of digital, physical, and biological spheres is revolutionising conventional education practices. In this study, a survey of 596 secondary school mathematics educators was administered to evaluate the correlation between online tool use and student performance through correlation analysis and multinomial logistic regression. Results showed a strong positive relationship between the use of online resources and student engagement, problem-solving, and academic achievements. The study calls for focused professional development and training activities to provide teachers with the knowledge and skills needed to use online resources in their classrooms. In addition, government and education stakeholders should invest in infrastructure to enable fair access to digital learning resources so that a sizable number of teachers and students can take advantage of technology-rich education.

Keywords: mathematics education, digital learning tools, technology integration, fourth industrial revolution, teachers' training, student engagement, educational technology

1. Introduction

The Fourth Industrial Revolution, marked by quick progress in digital tech and how it blends into all parts of society, is changing the education scene [9]. In this time of big changes, math education leads the way, aiming to get students ready to succeed in a world that's becoming more digital. Teachers are taking a fresh look at old ways to teach and learn math as they try to find new ideas to make the most of new tech [30]. This paves the way to explore how math education is changing in the Fourth Industrial Revolution era, with a focus on how online tools boost learning results [31]. By looking at where math education and digital progress meet, we will see how teachers are changing their methods to fit students' new needs in the digital world [1, 32]. Adding online tools to math education gives new chances to get students involved, make teaching personal, and help students understand concepts better. Interactive websites, virtual models, and smart learning programs give students learning experiences that fit their own needs and ways of learning [16].

In today's digital world, online tools have caused a revolution in how we teach and learn math [27]. These tools give students lively and hands-on ways to learn that make math more fun and easier to grasp. Let's look at the many ways people use online tools to make learning math better. One big plus of online tools is that

ORCID: 0000-0001-7075-2548 (O. O. Salami); 0000-0003-3073-9239 (E. D. Spangenberg)

Email: olajumokesalami1@gmail.com (O. O. Salami); ericas@uj.ac.za (E. D. Spangenberg)

Website: <https://fuoye.edu.ng/members/olajumoke-salami/> (O. O. Salami);

<https://www.uj.ac.za/members/prof-erica-spangenberg/> (E. D. Spangenberg)



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they can fit each student's needs and way of learning. Step-by-step guides you can click through, things you can move around on the screen, and lessons with pictures and sound let students learn math ideas at their own speed. This helps them get it by doing things themselves [8]. Because of the adaptive component of much of the software available online, real-time evaluation and feedback are possible so that educators can understand where students are struggling and deliver focused support to the students. Using algorithms and analytics, teachers are able to monitor learning progress, identify errors, and adapt instructional interventions to meet individual learning needs. The available online tools promote collaborative learning activities where students can interact with each other on a peer-to-peer basis, as well as solve problems together as a group, regardless of geographical position [10, 12, 25]. Virtual classrooms, discussion forums, and collaborative projects foster a sense of community and collective learning, enriching the educational experience beyond the confines of the traditional classroom.

Digital inclusion of online tools in mathematics teaching requires deep knowledge of important aspects that include digital equity, data privacy, and teacher preparedness. That technology and stable internet access should be available to every student to prevent differences in learning [22] is indeed critical. In other words, teachers also need to be trained well enough to use digital tools effectively in the classroom. Professional development programs related to digital literacy, teaching practices, and technical skills are the bedrock on which to build to better train and prepare educators to use online tools in a way that improves the learning of students. Digital resources can activate students, adapt learning experiences to student needs, and facilitate a richer knowledge and understanding of mathematical concepts [31]. By incorporating these tools, teachers can develop interactive, accessible learning communities that enable students to learn mathematics and more.

The pressure to enhance student performance has grown with programs such as the No Child Left Behind Act and by creating academic standards. Standardised tests, especially in mathematics, are frequently employed as an indicator of school performance, and the results may influence school funding, teacher hiring, or school administration [2]. In response to these high-stakes testing environments, teachers have sought professional development and classroom resources to enhance instruction.

While research shows that technology can enhance learning and support mathematics instruction [19, 20], not all teachers are quick to adopt these tools, nor do they always result in significant improvements in student outcomes. Continued research is needed to explore the intersection of technology, teacher practices, student engagement, and educational content, especially as the education system adapts to the demands of the Fourth Industrial Revolution. This paper examines how mathematics teachers used online tutoring platform and its connection to students' performance on standardised tests in this evolving educational landscape.

This study looks at how teachers use online mathematics tools to keep students motivated about learning mathematics and help them do better in school. There are studies in the literature that focus on the impact of using online tools to teach mathematics, but gaps exist in some areas. One major gap is that very marginal studies have been conducted on how online tools affect students with learning disabilities, also advanced students who are not in middle or high school have not been well researched. Another area that has not been well researched is addressing the uncertainties surrounding the optimal combination of online tools with classroom teaching for maximum benefit. Also, not a lot of research has been done on how customising material affects how well each person learns. To fill in these gaps, this study aims to answer three main questions: (i) How do online tools affect students'

ability to solve mathematics problems and gain mastery of the subject? (iii) How does personalising online tool content affect each student's learning outcomes; lastly (iii) How do teachers effectively combine online tools with classroom teaching to get all of their students involved?

Computer tools used in mathematics education have been looked at in earlier research, but this study adds new information in three main areas. First, it looks at how online mathematics tools affect students with different levels of skill, including those who have trouble learning. Second, it looks at how well teachers use internet-based tools to get their students more involved in the learning process. Third, it explores the effects of content customisation on individual learning outcomes. In addressing these aspects, this study offers a more comprehensive insight into how online resources support mathematics instruction across diverse educational settings. The results offer valuable implications for teachers, policymakers, and technology developers, ensuring more effective and inclusive digital learning environments in mathematics education.

2. Literature review

Although many students find mathematics a complex subject, it is considered a necessary part of K–12 education and a requirement for success in postsecondary education [23]. Specifically, completing mathematics in high school has been linked to increased career earnings, graduation rates, and access to colleges [21]. Mathematics standardised tests are essential since mathematics plays a big part in future success, and they have grown to be an essential part of today's educational environment, monitoring student progress, assessing teachers' efficacy, and contrasting national and international educational results. Numerous teachers are looking for instructional resources to help students improve their reasoning and content knowledge of mathematics due to ongoing concerns about students' poor performance. Although not all technological tools are adopted effectively or receive strong teacher support, strategic integration of technology can significantly enhance mathematics instruction [18, 35]. It offers students valuable opportunities to explore mathematical concepts in greater depth [26].

Teachers today have access to a wide range of instructional technologies. However, this study primarily focuses on online mathematics resources—web-based technologies designed explicitly for math education in the context of the Fourth Industrial Revolution. While educational technology encompasses tools like calculators or software such as word processors, this research zeroes in on the use of online platforms. Research shows that various methods are employed when integrating online mathematics resources in classrooms, leading to diverse impacts on the performance of students. The sections below present an overview of key studies examining the influence of technology on student outcomes and how mathematics teachers utilise these digital tools in their teaching practices.

2.1. Technology and students performance

There are many studies on the connection between computer technology and mathematical performance. Still, a recurring theme in these studies is the differing effects of the type and level of technology used. When computers were first used in classrooms to encourage higher-order thinking in their students, Zhang and Wang [36] discovered a positive correlation between computer use and mathematics performance. The correlation between mathematics performance and the use of computers for lower-order skills, however, was negative. This suggests that the way technology is applied has a significant influence on how well mathematicians perform. One important factor influencing the effect size was the technology used in the classroom. Numerous

studies have since been conducted to investigate the connection between student performance and the use of technology in school over the last 20 years. Current meta-analyses have focused on the influence of technology on pupil achievement in secondary mathematics, with a particular interest in how different approaches influence performance [17, 28, 29, 34].

One of the earliest systematic reviews on this topic was conducted by Yu, Li and Wang [34], who examined the effects of technology on secondary math outcomes across various educational programs, such as instructional processes, computer-assisted instruction (CAI), and curriculum innovations. The study defined CAI as technology that supports mathematics learning, including tools like self-paced modules, additional instruction in labs, and computer-managed progress tracking. Of the 100 studies studied, thirty-eight experimental studies showed a modest but positive effect size of +0.10 overall.

Further analysis revealed distinctions in how CAI was used: supplemental programs like PLATO, which support traditional instruction, had the largest effect size (+0.19), while core CAI (e.g., Cognitive Tutor) showed a smaller impact (+0.09). Computer-managed learning systems, such as Accelerate Mathematics, had a negligible or even negative effect (-0.02). This indicates that the type and implementation of online resources can influence student performance in mathematics.

Li, Zhou and Wijaya [17] also explored the effect of computer technology on student outcomes in mathematics across 46 studies, finding an average positive effect size of +0.28. Like Yu, Li and Wang [34], the research indicated that not all technological applications resulted in improved performance, with the method of implementation being a key factor. For example, technologies combined with constructivist teaching strategies resulted in greater gains than a traditional strategy. Also, work that included more than six months of technology implementation period showed greater effect sizes, thus reinforcing the value of long-term and thoroughly designed technology implementation in education.

In a recent analysis, Sun et al. [29] pointed out shortcomings of previous meta-analyses that had included studies with methodological design attributes that could have exaggerated effect sizes. With more stringent inclusion criteria, they distilled the field down to 75 studies concerning the application of online tools and computer technologies, such as interactive whiteboards. Results revealed a moderately positive, +0.15 effect of educational technologies on mathematics achievement. Their analysis went into the factors of grade level, kind of intervention, intensity of the program, and level of implementation to examine the effect of factors on effect sizes. In contrast to previous work, they did not detect any mean-effect size differences between primary and secondary grade levels.

However, like Yu, Li and Wang [34], Sun et al. [29] reported significant differences in the effect sizes according to the types of technologies used. Findings within most of the research were supplementary CAI (e.g., PLATO) and experienced the largest ES (+0.18). Additionally, a higher number of uses (at least 30 min/week) and program implementation level were correlated to larger effect size values, suggesting the role of both adherence to using and thorough adoption of educational technologies. A meta-analysis by Slavin, Cheung and Zhuang [28] that specifically looked at mathematics achievement with keen attention to algebra also discovered evidence that computer technology might help students perform better. When analysing 82 research that employed instructional techniques to boost student performance in mathematics, technology-based curricula showed statistically significant average effect sizes of +0.04, while technology tools demonstrated a higher weighted average effect size of +0.311. This suggests that while both technology-integrated curricula and tools positively influenced mathematics achievement, tools had a more substantial impact

on improving student outcomes. Online tools such as PLATO and Cognitive Tutor were used in technology curricula to facilitate or deliver mathematics instruction.

Conversely, “technology tools” referred broadly to items like interactive applets, computer programs, and calculators. In contrast to previous meta-analyses, this one had far broader inclusion criteria, looked at a more comprehensive range of achievement measures, and may have overstated the size of its stated effect sizes. The absence of effect sizes for various technology tools and curriculum types was noted in earlier meta-analyses as a significant differentiator in the efficacy of student performance outcomes. A great deal of research has been done over the past 20 years regarding how computer technology affects math performance in students (table 1). The use of online resources to augment regularly implemented instruction shows promise for improving academic performance; however, more research on these online mathematics resources is necessary due to the fluctuating effect sizes and ongoing technological advancements.

Table 1

Synopsis of meta-analyses on how technology affects mathematical performance.

Authors	Total number of studies	Total effect size
Yu, Li and Wang [34]	38	+0.01
Li, Zhou and Wijaya [17]	46	+0.28
Slavin, Cheung and Zhuang [28]	82	+0.04
Sun, Zhan, Wan, Yang and Looi [29]	74	+0.15

2.2. Teachers’ use of technology

The success of technology integration in mathematics teaching is contingent upon various factors, including the frequency of implementation, pedagogical design, and teacher implementation style. Literature has proven that constructivist methods using computers as explorative tools are more effective compared to conventional computation-based approaches [13]. Additionally, problem-solving activities in collaboration and interactive video tutorials have been found to yield beneficial impacts on students’ engagement and performance [6, 11]. Nonetheless, the effectiveness of technology is greatly reliant on pedagogical decisions. The replacement of traditional teacher instruction with technology is no assurance of improved outcomes [14]. The effectiveness of technology integration is contingent on the design of the tool, the teacher’s pedagogical approach, and the learning environment.

Teachers’ attitudes, professional development, and access to digital resources also significantly contribute to technology implementation [4, 36]. To foster the successful implementation of online teaching tools, teachers require professional development in integrating technology into curriculum [2]. Adoption is influenced by state standards, existing curriculum, school policies, and available resources [15]. Researchers ought to explore various pedagogical methods and contextual variables influencing the use of technology in classrooms in order to achieve optimum benefits [33].

2.3. Theoretical framework

It is necessary to have a model to comprehend how educators integrate technology in the classroom and how it influences learning for students. Albeshree et al. [4] pointed out that the success of educational technology relies on three elements: technology, teacher, and learning environment. Teachers’ attitudes, professional competencies, and pedagogical choices play a crucial role in the implementation and success of the tools [11, 36].

Technology use is also influenced by external circumstances like infrastructure availability, professional development, and education policy alignment [15, 33]. De Vita, Verschaffel and Elen [7] proposed the “technical demo” model, in which instructors showcase digital tools to learners in organised learning settings, emphasising the role of instructor facilitation in technology adoption.

The orchestration of instruments provides a useful model for investigating how teachers manage the use of digital tools in mathematics teaching. This study compares various models of implementation, including isolated remediation and collaborative learning, to determine the approaches that best enhance student engagement and comprehension [24].

3. Methodology

This section discusses the processes taken to achieve this study’s objectives, including the study design, population and sample, and other procedures.

3.1. Study design

This research adopts a cross-section research design, utilising statistical analysis to examine the relationship among variables. A cross-sectional survey method is employed to collect data at a specific point in time, providing an overview of the current state of the impact of online tools used in high schools in the region. This design is chosen for its ability to draw generalisable insights from a relatively large and diverse sample of school leaders, teachers, and administrators, facilitating the analysis of patterns and relationships between variables [5].

3.2. Population and sample

The population consists of teachers, mainly high school teachers. The list of teachers was obtained from the state education board, which served as the sampling frame. These teachers were sampled using online means. The data was collected between June and October 2024.

This data for this study was by primary source: both quantitative and qualitative survey data were collected from 596 secondary school mathematics teachers in Lagos and Abuja during the 2023-2024 academic year, reflecting a response rate above the online survey average reported [17]. The survey was obtained from academic years, and the focus was on middle and high school teachers to the end-of-course (EOC) exam’s role as a prerequisite in Nigerian education.

Two hundred and ninety-one (291) schools with teachers actively engaging with Algebra Nation versus 14 schools with no teacher logins, workbooks, or training. This method accounted for differences between groups, following a quasi-experimental approach to mitigate the influence of uncontrolled factors [3].

3.3. Data collection tools

A structured questionnaire was administered to the participants online to collect data (see the appendix A for the link to the survey). The questionnaire is divided into six sections:

- (i) General information
- (ii) Online mathematical use
- (iii) Student learning outcomes
- (iv) Student engagement
- (v) Support and resources
- (vi) Effectiveness and learning abilities

Also, participants were given questionnaires and semi-structured interviews to gain deeper insights into how online tools such as Algebra Nation, Khan Academy, Mathplanet, and GeoGebra help teach and learn mathematics, especially algebra. This combination of surveys and interviews allows for the triangulation of data, providing both broad quantitative insights and rich qualitative perspectives on the research topics.

3.4. Data analysis

Quantitative data analysis was performed using IBM SPSS Statistics, version 29. The analyses include descriptive statistics, such as frequencies, means, and standard deviations, to summarise general information and the responses from the questionnaires. Pearson's product-moment correlation was used to analyse the relationship between the variables. Also, multinomial logistic regression was conducted since the response variable is categorical, with the response variable classified as daily coded as 4, weekly coded as 3, occasionally coded as 2, and never coded as 1 to represent the use of online tools. The multinomial logistic regression is specified as follows:

3.4.1. Multinomial logistic regression

Multinomial logit models are useful in cases where the variable to be explained is nominal, and there is no order among the categories. They are termed as multinomial because the distribution of the dependent variable is multinomial in nature.

When constructing a multinomial logistic regression model, the result consists of multiple (greater than two or K) outcomes. We can conceptualise this scenario as fitting $K - 1$ separate binary logit models, with one of the outcomes serving as a reference point. The $K - 1$ outcomes are analysed in relation to the reference outcome.

$$\ln \left(\frac{p(Y_i = 1)}{p(Y_i = K)} \right) = \beta_{i1} X_i \quad (1)$$

$$\ln \left(\frac{p(Y_i = 2)}{p(Y_i = K)} \right) = \beta_{i2} X_i \quad (2)$$

up to the log odd ratio of

$$\ln \left(\frac{p(Y_i = K - 1)}{p(Y_i = K)} \right) = \beta_{ik-1} X_i \quad (3)$$

where $Y_i = 1, Y_i = 2$ are the categories in classification in the categorical response variable coded as $1, 2, \dots, K - 1$ and K is a category of reference. Taking exponential of both sides, we have,

$$p(Y_i = 1) = p(Y_i = K) = e^{\beta_1 X_i} \quad (4)$$

$$p(Y_i = 2) = p(Y_i = K) = e^{\beta_2 X_i} \quad (5)$$

then the term

$$p(Y_i = 1) = p(Y_i = K - 1) = e^{\beta_{K-1} X_i} \quad (6)$$

The linear form is

$$\ln \left(\frac{p(Y_i = 1)}{p(Y_i = K)} \right) = 1.638 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_{K-1} X_{K-1} \quad (7)$$

Interview data were thematically analysed using NVivo, seeking patterns and repetition in responses. The following analyses contextualise the quantitative findings by exploring the factors and perceptions that underpin the use of online tools in teaching mathematics.

3.5. Ethical considerations

This research followed ethical standards to protect the rights and privacy of the participants. All the participants voluntarily agreed to participate in the study, and their data would be kept secret. The Institutional Review Board at the university approved the study, following data protection rules for collecting and storing data. Participants could withdraw from the study at any moment without any penalty. Strict data protection procedures were used to maintain privacy and research ethics.

3.6. Instrument's validity

To ensure data reliability and validity, the research instruments underwent expert scrutiny and pilot study. Construct validity was established through internal consistency. Cronbach's alpha checks yielded 0.8942, indicating that the instrument is good for the study. Ethical clearance covered all the matters of data protection and security. The process of data collection ensured that results accurately captured participant responses and adhered to ethical research practices.

4. Results

This section discusses the results obtained. First, it summarises the demographic characteristics of the data obtained, followed by a multinomial logistics regression analysis.

The teachers who used online tools for less than a year were 231 (38.8%), 298 (50%) used online tools between 1-2 years, 46 (7.7%) used online tools between 2-3 years, and 21 (7.7%) used online tools for 3 years and above (figure 1).

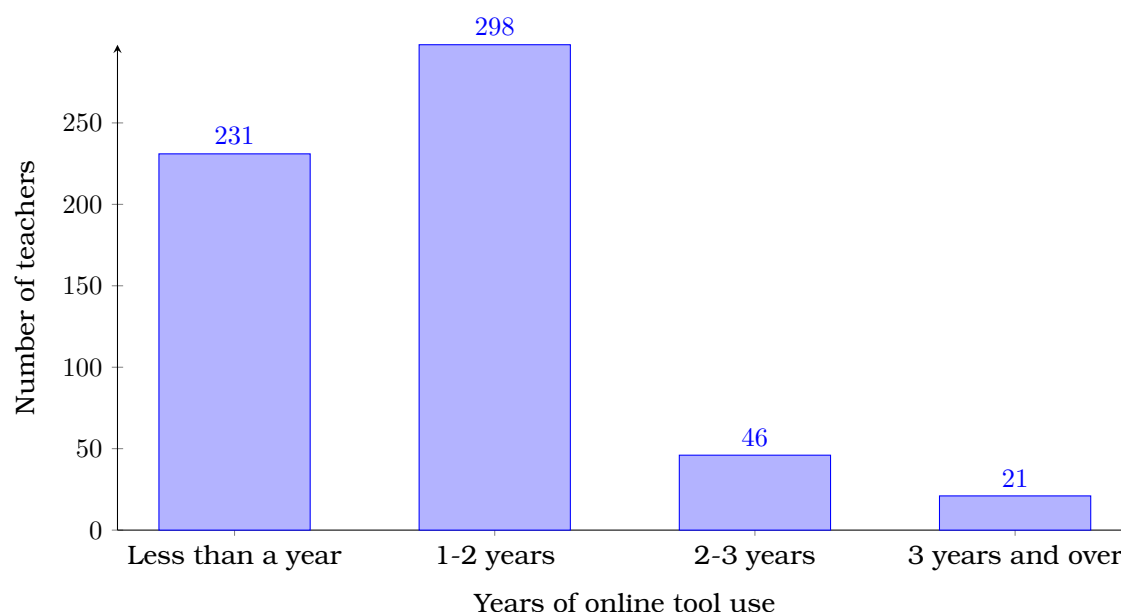


Figure 1: Period of use of online mathematical tools.

The teachers who use online mathematical tools weekly were 287 (48.2%), 249 (41.8%) use online tools daily, 46 (7.7%) use online tools occasionally, and 14 (2.3%) never used online tools (figure 2).

The teachers who use video lessons on the online tool were 93 (15.6%), 83 (13.9%) use practice problems feature on the online tool, 131 (22.0%) use assessments and quizzes features on Algebra Nation, 220 (36.9%) use interactive tools features on the online tool, and 69 (11.6%) use teachers resources features on the online tool (figure 3).

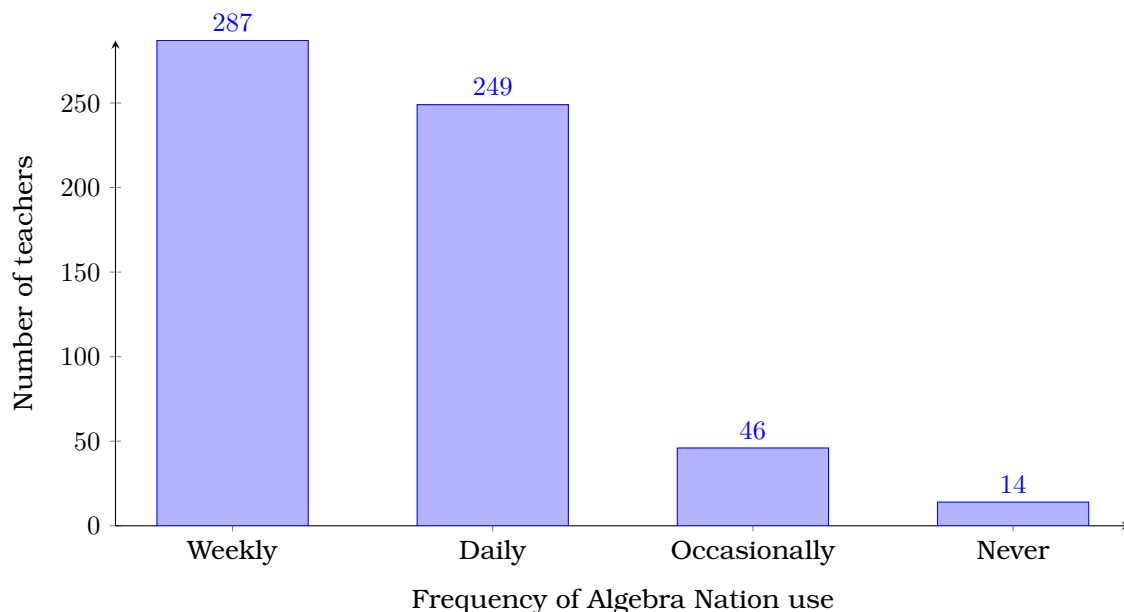


Figure 2: Frequency of use of online mathematical tools.

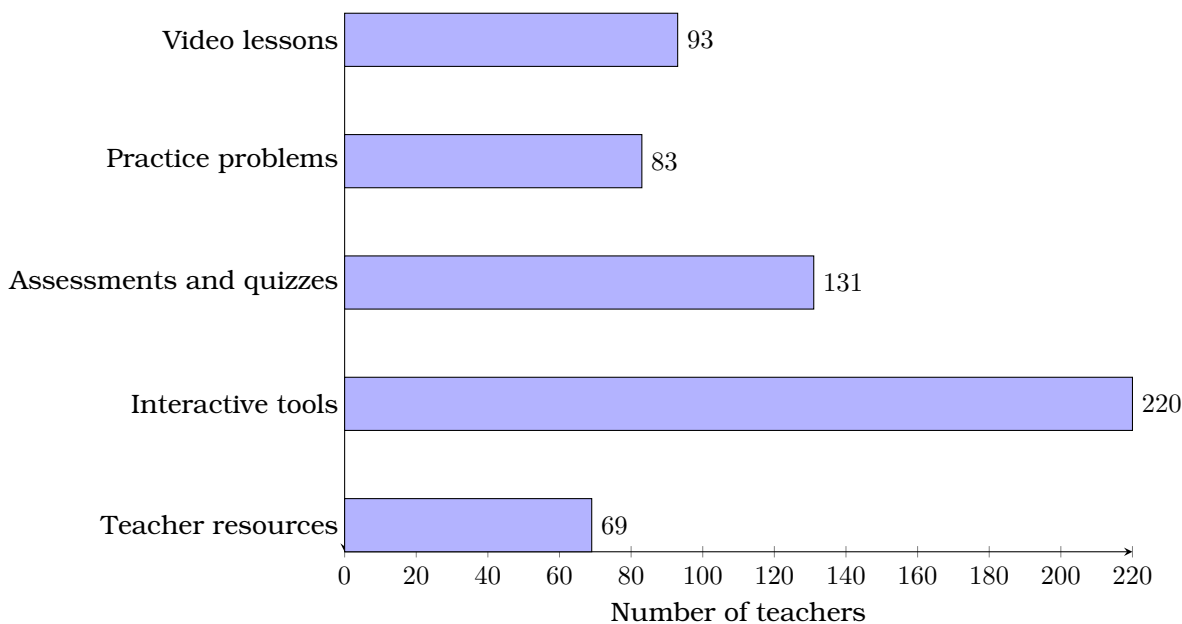


Figure 3: Feature of Algebra Nation used.

4.1. Research Question 1: How do teachers combine online tools with classroom instruction for optimal student engagement?

The results showed that the majority of teachers, 306 (51.3%), use online tools as supporting aids rather than as main pedagogical practices. The findings also show that teachers who use online tools more often (weekly or daily) have higher levels of student engagement than sporadic users.

The teachers who use Algebra Nation as a primary resource were 67 (11.2%), 306 (51.3%) use Algebra Nation as a supplementary resource, 120(20.1%) use online tool for-homework assignments, and 103 (17.3%) use online tool for in-class practice (figure 4).

The teachers who teach Basic 7 were 57 (9.6%), those who teach Basic 8 were 67

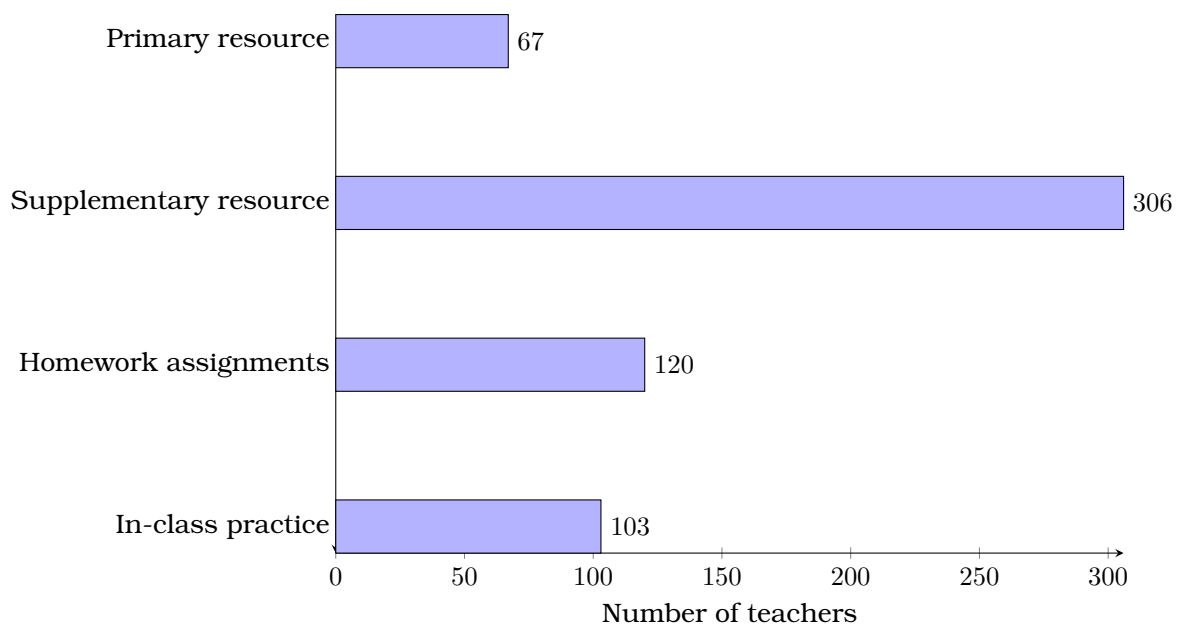


Figure 4: Integration of Algebra Nation into a lesson plan.

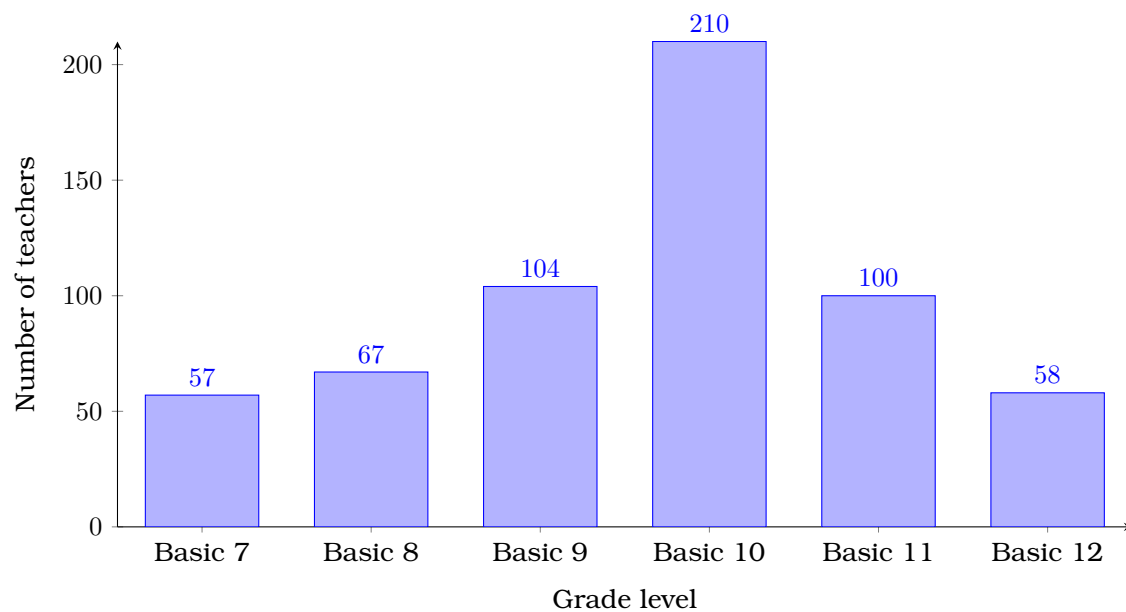


Figure 5: Classes taught by the teachers.

(11.2%), 104 (17.4%) teach Basic 9, 210 (35.2%) teach Basic 10, 100 (16.8%) teach Basic 11, and 58 (9.7%) teach Basic 12 (figure 5). Basic 7 to Basic 12 imply Junior Secondary School 1 (JSS 1) to JSS 3, then Senior Secondary School (SSS 1) to (SSS 3), making six grade classes altogether. Table 2 contains the summary statistics of the general information section.

The mean, median and mode of the five-point Likert scale are provided in table 2. Table 3 contains the Pearson correlation analysis of the variables in the study.

4.2. Research Question 2: How do online tools affect students’ problem-solving skills and conceptual understanding in mathematics?

The results (table 3) indicate a strong correlation between online tool use and student learning outcomes ($r = 0.9721$), online tool use and student engagement

Table 2
Summary statistics of the variables in figure 1 to figure 5.

	Grade taught	Period of use of online tool	Frequency of use of online tool	Feature of online tool used	Frequency of used of online tool in lesson plans
Number of valid responses	596	596	596	596	596
Mean	3.68	1.76	1.64	3.15	2.43
Median	4.00	2.00	2.00	3.00	2.00
Mode	4	2	1	4	2

Table 3
Correlation analysis of the variables in the study.

	Online tool use	Student learning outcomes	Student engagement	Support and resources	Effectiveness	Learning abilities
Online tool use	1					
Student learning outcomes	0.972076	1				
Student engagement	0.95958	0.931724571	1			
Support and resources	0.421791	0.421249798	0.394149	1		
Effectiveness	0.945013	0.921224158	0.905241	0.382027325	1	
Learning abilities	0.979036	0.95470573	0.938712	0.425158618	0.931459	1

has a strong relationship (0.9596), online tool use and support (0.42180) has a weak relationship, online tool use and effectiveness has a strong relationship (0.9450), online tool use and learning abilities have a strong relationship (0.9790). These findings suggest that interactive features and dynamic learning experiences provided by online mathematical tools enhance problem-solving skills and conceptual understanding. Student engagement, and support and resources have a weak relationship (0.3441). Lastly, support and resources, and effectiveness have a weak relationship (0.3820). Table 4 contains the likelihood ratio tests.

Table 4
Likelihood ratio tests.

Effect	Model fitting criteria		Likelihood ratio tests		
	-2 log-likelihood of reduced model		Chi-square	df	Sig.
Intercept	273.273		67.330	3	<.001
Support and resources	245.652		39.709	3	<.001
Overall effectiveness	213.011		7.068	3	.070
Student engagement	214.675		8.732	3	.033
Learning abilities	215.612		9.669	3	.022
Student learning outcomes	207.394		1.452	3	.693

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. An unexpected singularity in the Hessian matrix is encountered. This indicates that either some

predictor variables should be excluded, or some categories should be merged. By implication, student learning outcomes were not significant and could be removed from the model. Table 5 contains the multinomial logistics regression.

4.3. Research Question 3: How does the customisation of online tool content affect individual learning outcomes of the students?

The study underscores that although online tools generally enhance student learning, their effectiveness is contingent upon customisation. The multinomial logistic regression analysis (table 5) reveals that educators who incorporate customised online tools in teaching observe enhanced student engagement ($p = 0.021$) and enhanced learning outcomes ($p = 0.033$).

Table 5
Multinomial logistic regression analysis.

Algebra Nation use		B	Std. Error	Sig.
Never (1)	Intercept	-96.863	1749.037	.956
	Support and resources (SR)	-2.530	1.068	.018**
	Overall effectiveness (OE)	11.393	328.078	.972
	Student engagement (SE)	14.066	365.116	.969
	Learning abilities (LA)	-13.493	.000	.
	Student learning outcomes (LO)	9.514	281.538	.973
Occasionally (2)	Intercept	1.638	.801	.041 [^]
	Support and resources (SR)	-.711	.174	<. .001**
	Overall effectiveness (OE)	1.182	.541	.029*
	Student engagement (SE)	1.519	.659	.021*
	Learning abilities (LA)	-1.943	.911	.033*
	Student learning outcomes (LO)	-.279	.602	.643
Weekly (3)	Intercept	.144	.810	.859
	Support and resources (SR)	-1.008	.181	<. .001**
	Overall effectiveness (OE)	1.056	.496	.033*
	Student engagement (SE)	1.608	.632	.011*
	Learning abilities (LA)	-.805	.889	.365
	Student learning outcomes (LO)	-.721	.699	.302

* - significant at the 0.05 level ($p < 0.05$),
 ** - significant at the 0.01 level ($p < 0.01$),
[^] - indicates marginal significance ($p \approx 0.05$).

The reference category is *Daily*.

$$\ln \left(\frac{p(\text{Never} = 1)}{p(\text{Daily} = 4)} \right) = -96.863 - 2.530SR + 11.393OE + 14.066SE - 13.493LA + 9.514LO \quad (8)$$

Odds are the ratio of the probability of an event happening to the probability of an event not happening. The only significant variable with online tool use is support and resources (0.018), with a coefficient of -2.530. The coefficient has a negative impact on the log odds of the probability of support and resources for teachers who never use online tools to teach relative to those who use them on a daily basis. Teachers who do not use online tools see a reduction in assistance and resources by 2.530 compared to those who do.

$$\ln \left(\frac{p(\text{Occasionally} = 2)}{p(\text{Daily} = 4)} \right) = 1.638 - 0.711SR + 1.182OE + 1.519SE - 1.943LA - 0.279LO \quad (9)$$

From the table 5, SR, OE, SE and LA are significant with probability values of <0.001, 0.029, 0.021, and 0.033, respectively.

Teachers who use online tools occasionally to teach relative to teachers who use them daily reduce support and resources by 0.711, increase overall effectiveness by 1.182, increase students' engagement by 1.519, and reduce learning abilities by 1.943.

$$\ln \left(\frac{p(\text{Weekly} = 3)}{p(\text{Daily} = 4)} \right) = 0.144 - 1.008SR + 1.056OE + 1.608SE - 0.805LA - 0.721LO \quad (10)$$

From the table 5, SR, OE, and SE are significant with probability values of <0.001, 0.033, and 0.011, respectively. Teachers who use online tools weekly to teach relative to teachers who use them daily reduce support and resources by 1.008, increase overall effectiveness by 1.056, and increase student engagement by 1.608.

4.4. Qualitative analysis

Thematic analysis of the responses of educators who are using online mathematical tools in their classroom practices provided a significant understanding of the utility and challenges regarding the effectiveness of an online mathematical tool. Emerged two major themes: challenges regarding its integration with classroom instructions. A summary of the analysis of responses is presented in tables 6 and 7 below.

Table 6

Thematic analysis of responses on desired features and resources in online mathematical tool.

Themes	Second-level codes	First-level codes
Enhanced features	Advanced customization tools	"We need more tools to modify content for students with varied abilities, including gifted students and those with learning disabilities."
	Gamification of learning	"Incorporating gamified elements could make learning mathematics more engaging and fun for students."
	Virtual collaboration spaces	"It would be helpful to have features where students can collaborate in real-time on problem-solving tasks."
Additional resources	Expanded video library	"A wider range of video lessons covering different topics in depth would benefit both teachers and students."
	Teacher training modules	"Professional development materials on effectively using online tools in teaching would improve its impact."

4.5. Themes and discussions

4.5.1. Theme 1: Enhanced features and resources

Educators wished for more advanced customisation tools and a wider range of instructional content. Gamification and virtual collaboration spaces were recommended to better engage students and enhance peer interaction. These insights show that digital tools will need to be continuously updated to meet the diverse needs of learners.

4.5.2. Theme 2: Challenges in using online mathematical tool

The main issues were infrastructure limitations, such as bad internet and a lack of devices. One of the other major issues was teacher preparedness; teachers felt they needed more focused training on how to use an online math tool effectively. Students'

Table 7

Thematic analysis of responses on challenges in using the online mathematical tool.

Themes	Second-level codes	First-level codes
Infrastructure issues	Internet connectivity	“Unreliable internet makes it hard to access online mathematical tool consistently during lessons.”
	Access to devices	“Some students lack access to the devices needed to use the platform effectively.”
Teacher preparedness	Limited training	“Not all teachers are trained on how to maximise online mathematical tool’s features for classroom use.”
	Resource constraints	“Limited access to supplementary resources reduce the platform’s effectiveness.”
Student engagement	Resistance to technology	“Some students prefer traditional methods and find it hard to engage with online tools.”

engagement was also an issue, as some were not comfortable learning in an online environment.

5. Discussion

The results from this study showed important insight regarding high school teachers’ use of online math tools and their impact on teaching and learning. The information showed that most teachers have been using the tools for between 1 and 2 years (50%), and more (38.8%) have been using them for less than a year. This shows that the use of online tools is a relatively recent occurrence, pointing to the ongoing move towards online practice in teaching. On how frequently they use them, nearly half of the teachers (48.2%) reported using online tools weekly, and 41.8% use them daily. This indicates that numerous teachers recognise the value of these tools for instruction. However, 7.7% use online tools sometimes, and 2.3% never use them, which indicates that there are likely difficulties associated with the use of these tools that must be studied further.

The research also analysed the features of online teachers’ tools. The most widely used features included interactive tools (36.9%) and assessments/quizzes (22.0%), with a preference for interactive and evaluative features. Video lessons (15.6%), practice problems (13.9%), and teacher resources (11.6%) were used by fewer teachers. The trends indicate that teachers favour dynamic, student-centred features compared to passive content consumption. The incorporation of online tools into lesson plans also highlights their instructional role. Most (51.3%) of the teachers utilise online tools as supplementary materials instead of primary instructional approaches. Another 20.1% utilise them for homework, and 17.3% use them for in-class practice. Just 11.2% use online tools as primary materials, which supports the view that digital tools augment, not supplant, conventional instruction.

The correlation analysis indicates the high correlations between online tool usage and student learning outcomes ($r = 0.9721$), student engagement ($r = 0.9596$), and learning capacities ($r = 0.9790$). The findings are consistent with earlier research showing that technology-supported learning contexts support higher levels of student engagement and conceptual comprehension [17, 34]. In particular, the weak relationship between online tool usage and support/resources available ($r = 0.4218$)

indicates that infrastructural and institutional issues could be impeding teachers' successful use of technology. This is in line with concerns within the literature about digital equity and professional development opportunities [2, 33]. The multinomial logistic regression analysis also provides insight into teacher behaviour. Relative to daily users, online tool occasional using teachers perceive declines in support and resources ($\beta = -0.711$, $p < 0.001$) and learning capacity ($\beta = -1.943$, $p = 0.033$). On the other hand, they perceive greater overall effectiveness ($\beta = 1.182$, $p = 0.029$) and student engagement ($\beta = 1.519$, $p = 0.021$). Likewise, weekly online tool-using teachers also have significant gains in overall effectiveness ($\beta = 1.056$, $p = 0.033$) and student engagement ($\beta = 1.608$, $p = 0.011$). These results imply that though occasional and weekly users continue to gain from online tools, daily users might have more support mechanisms that enable seamless integration with lesson planning on a daily basis.

Also, the non-significant and weak association of student learning outcomes and online tool use in the likelihood ratio test ($\chi^2 = 1.452$, $p = 0.693$) implies that although engagement and effectiveness are enhanced, direct improvement in observable academic performance could be contingent on other factors, including curriculum alignment, student motivation, and assessment. This would mean that online tools ought not to be considered autonomous solutions but instead as supplementary teaching aids that need appropriate scaffolding and pedagogical support.

In spite of the generally beneficial impacts of online tools, the research also identifies a significant limitation: the degree to which these tools can be tailored to meet varied learning requirements. The results indicate that although online tools improve general learning outcomes, their flexibility for adapting to students with exceptional abilities or disabilities has yet to be fully investigated. Future studies should research online learning environments in relation to online teaching and tools to meet the needs of a wider variety of student abilities.

6. Implications

This study has various implications for both policy and practice in mathematics education, such as:

1. *Teacher training and development*: The robust correlation between online tool utilisation and student outcomes highlights the necessity for professional development initiatives to improve teachers' digital literacy and pedagogical competencies. Workshops aimed at incorporating online technologies into current curricula and tailoring materials for varied learning requirements are crucial.
2. *Infrastructure and resource allocation*: The relatively poor link between support/resources and online tool use underscores the necessity of enhancing infrastructure, particularly dependable internet access and suitable digital tools. Policymakers should prioritise investments in educational technology to eliminate inequities and increase fair access.
3. *Curriculum integration*: The increasing usage of online tools as a supplementary resource highlights the necessity for intentional curriculum design that effectively integrates online technologies. Developing frameworks for hybrid teaching approaches will ensure that digital resources complement traditional training efficiently.
4. *Future research* should study the long-term impacts of online tools on different student populations, including those with disabilities and gifted learners. Additionally, researching the connection between the customisation of material and individual learning outcomes will provide useful information for tool makers and educators.

7. Limitations

Although this study contributes significantly to the literature on using online mathematical tools in high school education, it has several limitations. First, the study relies on self-reported survey data, which may introduce response bias. Teachers' perceptions of their online tool usage and effectiveness may not always align with actual classroom practices. Future research could incorporate classroom observations and student performance assessments for a more objective evaluation.

Second, it is limited by the geographic and educational context within which the current study was framed. Variability in curriculum imperatives, technology infrastructure, and teacher training programs across regions makes the generalizability of findings different. Comparative research across a diverse range of settings would serve as a validation to extend these results.

Third, though the present study has shed light on general effectiveness, it failed to explain the variation between different kinds of online mathematical tools. Interactively, different types of tools, such as interactive simulations, virtual manipulatives, and assessment platforms, may impact student learning. The relative effectiveness of different types of online math tools is an issue that needs further study.

The study also fails to explain other external variables, such as administrative support, school policies, and students' access to technology outside the classroom. These contextual elements are very important in explaining the outcomes of technology integration in education and are worthy of further investigation.

Given these limitations, the outcomes are a good contribution to the continuous discussion about the process of digitisation within mathematics education and serve as a point of further investigation and elaboration in order to achieve the most optimal utilisation of online tools during teaching and learning.

8. Conclusion

This study highlights the significant contribution of internet-based tools to the learning of mathematics. High correlations were found between their usage and increased student learning outcomes, engagement, and teaching effectiveness. More than presenting these findings, it is necessary to consider their implications more broadly.

For educators, professional development programs should emphasise providing educators with the skills to enable them to successfully incorporate digital tools into instructional practices. For policymakers, investments must be directed toward technological infrastructure to promote equitable access to resources, especially in disadvantaged areas. For curriculum developers, hybrid models of learning should be created that can successfully combine digital tools with conventional methods of teaching to enhance student engagement and understanding.

Moreover, future research needs to examine the long-term impact of digital tools on students' achievement based specifically on how various methods of customisation affect learners with varying capabilities. Also, future research should further explore the connection between pedagogical approaches and technology adoption to optimise educational outcomes. By fostering a digitally inclusive learning environment, stakeholders can utilise technology to assist learning differences as well as general learning performance.

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Declaration on generative AI: AI was used for grammar to make reading more appealing.

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A. Google Forms link

<https://forms.gle/BR9LUHQ4VZEhBVvV8>