World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

The challenges and opportunities of teaching mathematics online at the higher levels in region 6, Guyana: A pilot study

Aarif Baksh [1], Lakhnarayan Kumar Bhagarathi [1, 2, *] and Bibi Rafeena Ally-Charles [3]

[1] *Faculty of Natural Sciences, University of Guyana, Berbice Campus, Tain, Corentyne, Guyana.*
[2] *Faculty of Natural Sciences, University of Guyana, Turkeyen Campus, Greater Georgetown, Guyana.*
[3] *College of Medical Sciences, University of Guyana, Turkeyen Campus, Greater Georgetown, Guyana.*

World Journal of Advanced Research and Reviews, 2025, 25(03), 495-509

Publication history: Received on 30 January 2025; revised on 05 March 2025; accepted on 07 March 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.3.0757

Abstract

This study assesses the preference of educators towards teaching mathematics via different environments, and the challenges and opportunities of teaching mathematics online at the upper secondary and tertiary levels in Region 6, Berbice, Guyana. This study was conducted during the COVID-19 pandemic in the year 2021. Thirty-five mathematics educators from both secondary and tertiary intuitions across Region 6, Berbice were surveyed. A questionnaire was created via Google forms and distributed online to the participants. The questionnaire was designed with two themes and was based on a 5-point Likert scale. Results showed that educators preferred face to face and blended teaching over online teaching. Many of the educators claimed that the most popular virtual tool used was videos. Many of the educators agreed to facing several challenges in teaching mathematics online. Most of the educators agreed to facing challenges such as difficulty writing mathematical symbols on the screen, switching between multiple screens, viewing and commenting on student's work, preparing mathematical content for online learning, engaging students in mathematical thinking, constructing higher-order questions, and setting tests with high levels of integrity. The most frequent challenge that educators agreed to was difficulty in engaging students in mathematical thinking online. Many educators agreed that opportunities for improving mathematics education in the online environment exist. A considerable number of educators believe that they are many opportunities for improving mathematics via the online environment such as mathematical software to enhances students' understanding of the concepts and to render mathematical symbols on screen, specialized package on how to teach mathematics in the online environment for mathematics teacher and mathematics education, specialized training on how to construct mathematics questions that test higher order thinking skills and to construct mathematics questions that with high integrity in the online environment.

Keywords: Mathematics; Challenges; Opportunities; Teaching; Online; Secondary; Tertiary

1. Introduction

1.1. Mathematics and modality of delivery

Historically, mathematics education is intricately interwoven in the development of civilization; civilization advances when mathematics advances [6]. Even now, there seems to be a global focus on mathematical achievement as a gateway to economic prosperity [4]. It is therefore no coincidence that leaders of many Western nations are anxiously anticipating improved results in international performance indicators such as the Trends in International Mathematics and Science Study (TIMSS) [4] [6].

* Corresponding author: Lakhnarayan Kumar Bhagarathi

Mathematics education prospers in the face-to-face environment [17]. This premise is based on the fact that mathematics is an abstract discipline that requires that teachers interpret the specific lines of mathematical reasoning that each student has engaged [2]. To accomplish this task, the teacher employs a range of pedagogical strategies such as peer collaboration, the use of manipulatives, visual representation, schema-based instruction, and problem-solving [5] [14].

The arrival of the COVID-19 pandemic in the year 2019 has forced the near-total discontinuation of face-to-face interactions at educational institutions worldwide and in response to this unavoidable closure, education stakeholders were compelled to transition from the face-to-face environment to online delivery [17]. At most secondary and tertiary schools in Guyana, mathematics classes are blended, while mathematics classes at the University of Guyana are conducted either face to face, fully online, or by utilizing the hybrid mode of delivery.

A range of computer hardware and software technologies are used to facilitate teaching, learning, and assessments in online classes. The more popular hardware components are computers, tablets, and cellular phones while some common software implements include Moodle, zoom, WhatsApp, and Google Classroom. While these components are effective in the delivery of courses in certain areas, the peculiarity of mathematics as a quantitative science requires that some amount of differentiation be considered.

Mathematics teachers find it challenging to provide feedback on students' classwork, and to construct questions to test higher-order skills and simultaneously maintain a high level of integrity. In the same light, there are opportunities to explore hardware and software components such as digital pads, simulators, graphing calculators, and equation solvers that aid the delivery of online mathematics.

This novel research aimed to investigate the challenges encountered by educators and the opportunities provided in teaching mathematics online at the upper secondary and tertiary levels in Region 6, Berbice, Guyana. A review of the literature shows that research of this nature was never conducted in Guyana.

1.2. The Impetus for Online Learning

Extensive online and face-to-face educational reform is pervasive on a global scale, particularly in the area of mathematics and statistics [15]. The interest in online learning has grown because of advances in technology and for quite some time, educators have been experimenting with online learning [15]. The aim of online learning is for educators to develop new and engaging curricula that promote "conceptual" understanding instead of the conventional "procedural" understanding. To achieve this aim, educators are encouraged to attempt new teaching strategies based on the integration of mathematical and statistical software and the implementation of inter-disciplinary online collaborative learning and support [16].

1.3. The Traditional vs the Face-to-Face Environment

Many educational institutions have resorted to online learning to replace traditional classroom interactions as a way to mitigate the spread of the COVID-19 virus. The online environment eliminates physical barriers to classes, provides flexibility and increased convenience, and promotes customized learning [37]. Opponents of online learning, however, contest that students in online classrooms may have diminished interest in the subject, feelings of isolation, and frustration [20].

In terms of a comparison of performance, the literature elicited similar conclusions. McLaren (2004) reported that there was no significant difference in the final performance of students between the two modes of instruction. In separate studies, Werhner (2010) and Stack (2015) arrived at the same conclusion based on their experiments with online and face-to-face classes. Harrington (1999) compared the performance of master's level social work students using both instructional modes and his results suggested student performance is independent of the mode of instruction provided that the student was previously academically successful. Instead of trying to ascertain the dominance of one of the two modes of instruction, Keegan (1993) posited that online learning is meant to complement face-to-face education rather than replace it, and therefore a blended approach should be considered which combines the best of both environments.

1.4. Challenges of Teaching Mathematics in the Online Environment

The urgency to move to online learning as a result of the pandemic was a novelty experience and most educators were underprepared [29]. Educators were placed in an uncomfortable situation where they had to use unfamiliar online platforms for teaching and for which they had not received any prior training. Cassibba *et al.* (2021) suggested that there are two important aspects to consider when teaching mathematics in the online environment: 1) the formality of the subject which involves the use of many mathematical symbols and formulas and 2) the specificity of the audience (class) which they explained, required a different approach for teaching mathematics to mathematics majors compared to mathematics to other majors. Irfan *et al.* (2020) concluded from their study of online mathematics in Indonesia that lecturers were limited in their ability to present materials, particularly mathematical symbols and equations, as well as videos and PowerPoint.

In 2021, Cassibba *et al.* explained that "objectification" may be an issue in the online environment as teachers who were very tied to the blackboard were losing their physical dimension and so have lost the convenience of expression. Objectification is defined as the learning process that allows students to learn abstract mathematical concepts with the use of familiar objects and metaphors.

Loomis in 2020 suggested that the biggest obstacles to online mathematics education were monitoring students' thinking, and designing curriculum and instruction to fit the online environment. Additionally, Cassibba *et al.* (2021) explained that the online platform is a complex system involving not only the delivery of content but also making appropriate choices of technology, methodology, and theoretical models. Essentially, the role of instructional design is different in the online environment compared to the face-to-face environment [13]. Gadanadis *et al.* (2002) further explained that consideration must be given to assessment strategies specifically designed for online testing about being able to maintain quality evaluation.

1.5. Opportunities for Teaching Mathematics in the Online Environment

Currently, the landscape of online mathematics is rapidly changing. Apart from the unique set of challenges experienced in the teaching of online mathematics, the opportunity to use the online platform to expand the boundaries of mathematics education also exists. Moreover, Cassibba *et al.* (2020) observed that lecturers have adapted to the online mode of instruction and have incorporated various new artifacts (e-learning platforms, writing tablets, mathematical software) to increase their effectiveness in the online environment.

Sinclair & Crespo in 2006 highlighted that three features of dynamic computer environments allow students to learn important mathematical concepts and processes that are otherwise challenging to learn in non-technological contexts. These features are continuous motion, connectivity, and communication. Continuous motion allows for the manipulation of mathematical objects by changing their shape or form, connectivity allows for the fluid motion between different mathematical perspectives (for example the geometric and algebraic interpretations of a solution to a system of simultaneous equations) and communication involves the availability of mathematical jargons to classify mathematical objects in a mathematical software. In addition, Gadanadis *et al.* (2002) also highlighted that mathematics communication should become easier once there is accessibility to mathematical objects that are easily manipulated for both teachers and students.

Furthermore, Sinclair & Crespo (2006) outlined that there should be a balance of experiences in the online environment including demonstration, experimentation, and performance. They also posited that students should be motivated to think mathematically. Huang (2019) explained that the theoretical framework of mathematics education in the online environment differs significantly from the face-to-face environment and therefore teachers must be adequately trained to be effective in delivering mathematics in the online environment.

The objective of this study was to assesses the preference of educators towards teaching mathematics via different environments and the challenges encountered by educators and the opportunities provided in teaching mathematics online at the upper secondary and tertiary levels in Region 6, Berbice, Guyana.

2. Methodology

2.1. Population and Sample of the Study

The population of interest was secondary and tertiary Mathematics educators in Region 6, Berbice. The online survey was administered to four Mathematics lecturers at the University of Guyana Berbice Campus and a sample of secondary school Mathematics teachers who are utilizing the online environment were selected at random from the seventeen secondary schools within the region. The total sample size was thirty-five (n=35).

2.2. Instrument for Data Collection

A questionnaire with a total of nineteen items was constructed using Google Forms and distributed online to the participants. The two themes explored were "challenges" and "opportunities". The items related to these two themes were based on a 5-point Likert scale. The options were coded with the numbers 1-5 where a higher number indicates a greater level of agreement with the statements.

2.3. Reliability Analysis

The challenges subscale comprised of seven items (α=0.805) was found to be of good reliability. The opportunities subscale which consisted of six items (α=0.791) was found to be of acceptable reliability. For both subscales, all items are worthy of retention as any deletion of items seemed not to increase α significantly, if at all.

3. Result and Discussion

Table 1 Participants Age and Preferred Mode of Delivering Mathematics

Age Range * Pref Env Crosstabulation						
			Pref_Env			**Total**
			Face-to-Face	**Online**	**Blended**	
AgeRange	16 – 20	Count	1	0	0	1
		% within Age_Range	100.0%	0.0%	0.0%	100.0%
		% within Pref_Env	5.6%	0.0%	0.0%	2.9%
		% of Total	2.9%	0.0%	0.0%	2.9%
	21 – 30	Count	9	0	10	19
		% within Age_Range	47.4%	0.0%	52.6%	100.0%
		% within Pref_Env	50.0%	0.0%	62.5%	54.3%
		% of Total	25.7%	0.0%	28.6%	54.3%
	31 – 40	Count	7	1	3	11
		% within Age_Range	63.6%	9.1%	27.3%	100.0%
		% within Pref_Env	38.9%	100.0%	18.8%	31.4%
		% of Total	20.0%	2.9%	8.6%	31.4%
	41 – 50	Count	0	0	3	3
		% within Age_Range	0.0%	0.0%	100.0%	100.0%
		% within Pref_Env	0.0%	0.0%	18.8%	8.6%
		% of Total	0.0%	0.0%	8.6%	8.6%
	Over 50	Count	1	0	0	1
		% within Age_Range	100.0%	0.0%	0.0%	100.0%
		% within Pref_Env	5.6%	0.0%	0.0%	2.9%
		% of Total	2.9%	0.0%	0.0%	2.9%
Total		Count	18	1	16	35
		% within Age_Range	51.4%	2.9%	45.7%	100.0%
		% within Pref_Env	100.0%	100.0%	100.0%	100.0%
		% of Total	51.4%	2.9%	45.7%	100.0%

Table 1 shows that more than half (54.3%) of the participants were within the age range of 21 – 30 with the preference for environment divided almost equally between face-to-face and blended (47.4% and 52.6% respectively). The second most frequent age range is 31 – 40 (31.4%) and within this group, 63.6% of participants preferred the face-to-face environment and 27.3% preferred the blended environment. The three participants (8.6%) within the 41 – 50 age range all preferred the blended environment. There was only one participant within each of the extreme age ranges (16 – 20 and Over 50) and they both preferred the face-to-face environment.

A bit over half (51.4%) of all participants preferred to use the face-to-face mode to teach mathematics and 45.7% of all participants preferred the blended mode. Only one participant (2.9%) in the entire survey preferred to use the online environment.

Table 2 Virtual Tools used by Respondents to teach Mathematics

Virtual Tools Frequencies				
		Responses		**Percent of Cases**
		N	**Percent**	
$Virtual_Tools[a]	Virtual White Boards	18	15.5%	51.4%
	Virtual Text Books	16	13.8%	45.7%
	PowerPoint Presentations	25	21.6%	71.4%
	Videos	32	27.6%	91.4%
	Digital Writing Pads	7	6.0%	20.0%
	Virtual Simulators	3	2.6%	8.6%
	Graphing Calculators	10	8.6%	28.6%
	Equation Solvers	5	4.3%	14.3%
Total		116	100.0%	331.4%
a. Dichotomy group tabulated at value 1.				

Respondents were required to select as many online tools that they used in their classroom to teach online mathematics. Table 2. shows that the generic virtual tools lead the way in terms. The most popular tool used was videos (32 respondents or 91.4%) followed by PowerPoint presentations (25 respondents or 71.4%). While PowerPoint presentations were not popularly used in Indonesia as explained by Irfan *et al.* (2020) in the literature, it is a staple for online education in Region 6, Guyana. About half (51.4%) of the respondents used virtual whiteboards followed closely by virtual textbooks which were used by 16 (45.7%) of the respondents. Table 2 also revealed that the more mathematics-specific tools were used to a lesser extent in the online classroom. The most popular tools in this category were graphing calculators which were used by a bit over a quarter (28.6%) of the respondents, and digital writing pads which were used by one-fifth of the respondents. The least used tools were equation solvers (5 respondents or 14.3%) and virtual simulators (3 respondents or 2.6%).

Senyefia (2017) investigated the impact of physical and virtual manipulatives on junior high school students' understanding of geometric transformations in Ghana. The quasi-experimental study found that both types of manipulatives significantly improved students' mathematical achievements, with virtual manipulatives showing a slightly higher effectiveness. The research suggests incorporating manipulatives into teaching strategies to enhance conceptual understanding.

Simonetti *et al.* (2021) explored the use of virtual reality (VR) in teaching complex mathematical and physical concepts to high school students. The immersive VR environment aimed to enhance spatial understanding and reduce information dispersion compared to traditional two-dimensional teaching methods. Feedback from student participants indicated that VR significantly improved their comprehension of the subjects studied, suggesting that VR can be an effective supplementary tool in mathematics education.

Mathews *et al.* (2022) developed VedicViz, a web-based platform that visualizes techniques from Vedic Mathematics to aid in mental arithmetic. The tool provides dynamic visualizations for operations such as addition, multiplication, and square root extraction, facilitating a comparative understanding between traditional methods and Vedic approaches. Evaluation with high school students demonstrated that VedicViz is a valuable resource for practicing and learning mental computation techniques.

Dana-Picard (2023) examined the role of computer algebra systems (CAS) and dynamic geometry software (DGS) in transforming mathematics education into an exploration-discovery-conjecture-proof paradigm. The study emphasized the importance of integrating automated tools to foster critical thinking, collaboration, and communication among students. Examples from various mathematical domains illustrated how these technologies can enhance understanding and engagement.

Agyei *et al.* (2024) conducted a situational analysis of high school teachers' experiences with digital technologies in teaching mathematics in Ghana. The study found that while digital tools have the potential to enhance teaching and learning, challenges such as inadequate infrastructure and limited teacher training hinder effective implementation. The authors call for targeted professional development and investment in resources to support the integration of technology in mathematics education.

Table 3 Challenges of Delivering Mathematics in the Online Environment

Challenges	**Response options**				
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
I am limited by ability to write mathematical symbols on the display screen.	6	15	10	4	0
I encounter difficulties in switching between multiple screens (for example: between the textbook, virtual whiteboards and a graphing calculator) for the purpose of explaining a topic.	11	10	5	7	2
I am unable to see students' work and therefore I am unable to comment on their progress.	14	10	6	4	1
I find it difficult to prepare mathematical content adapted to the online environment.	6	9	9	9	2
I find it challenging to engage students in mathematical thinking in the online environment.	11	12	6	6	0
I find it challenging to construct questions which test students' higher order thinking skills.	6	9	10	7	3
I find it challenging to construct tests and assignments with high levels of integrity.	8	10	9	7	1

Salami and Spangenberg (2024) conducted a survey involving 596 secondary school mathematics educators to evaluate the correlation between the use of online tools and student performance. The study revealed a strong positive relationship between the utilization of online resources and improvements in student engagement, problem-solving skills, and academic achievements. The authors recommend professional development for teachers and investment in infrastructure to facilitate the effective integration of digital tools in mathematics education.

Estonia's education system is recognized for its high performance in mathematics, attributed to a curriculum that emphasizes problem-solving, critical thinking, and extensive use of technology. Students engage with digital tools, including virtual reality, from an early age, which has been linked to improved learning outcomes. This approach demonstrates the potential benefits of integrating technology into mathematics education to foster student engagement and achievement [40].

A recent article highlighted the increasing use of AI-powered applications, such as Gauth, by high school and college students to assist with mathematics homework. These tools allow students to capture images of problems and receive step-by-step solutions generated by AI. While these applications provide accessible support, there are concerns regarding their impact on critical thinking and learning processes, emphasizing the need for guided and appropriate use in educational settings [45].

Yue *et al*. (2024) introduced MathVC, a virtual classroom powered by large language models (LLMs) designed to simulate multiple student characters for collaborative mathematical modeling. The system aims to provide students with opportunities to practice mathematical modeling skills through group discussions in a virtual environment. Experimental results indicated that MathVC effectively simulates authentic student interactions, offering a promising tool for enhancing mathematics education.

Tayfour and Alibraheim (2025) conducted a quasi-experimental study in Bahrain to assess the impact of virtual laboratories on fourth-grade students' mathematical power and their attitude towards mathematics. The study revealed that students who engaged with virtual labs showed significant improvements in mathematical proficiency and developed a more positive disposition towards the subject. The authors advocate for the integration of virtual labs into primary education curricula to enhance learning outcomes.

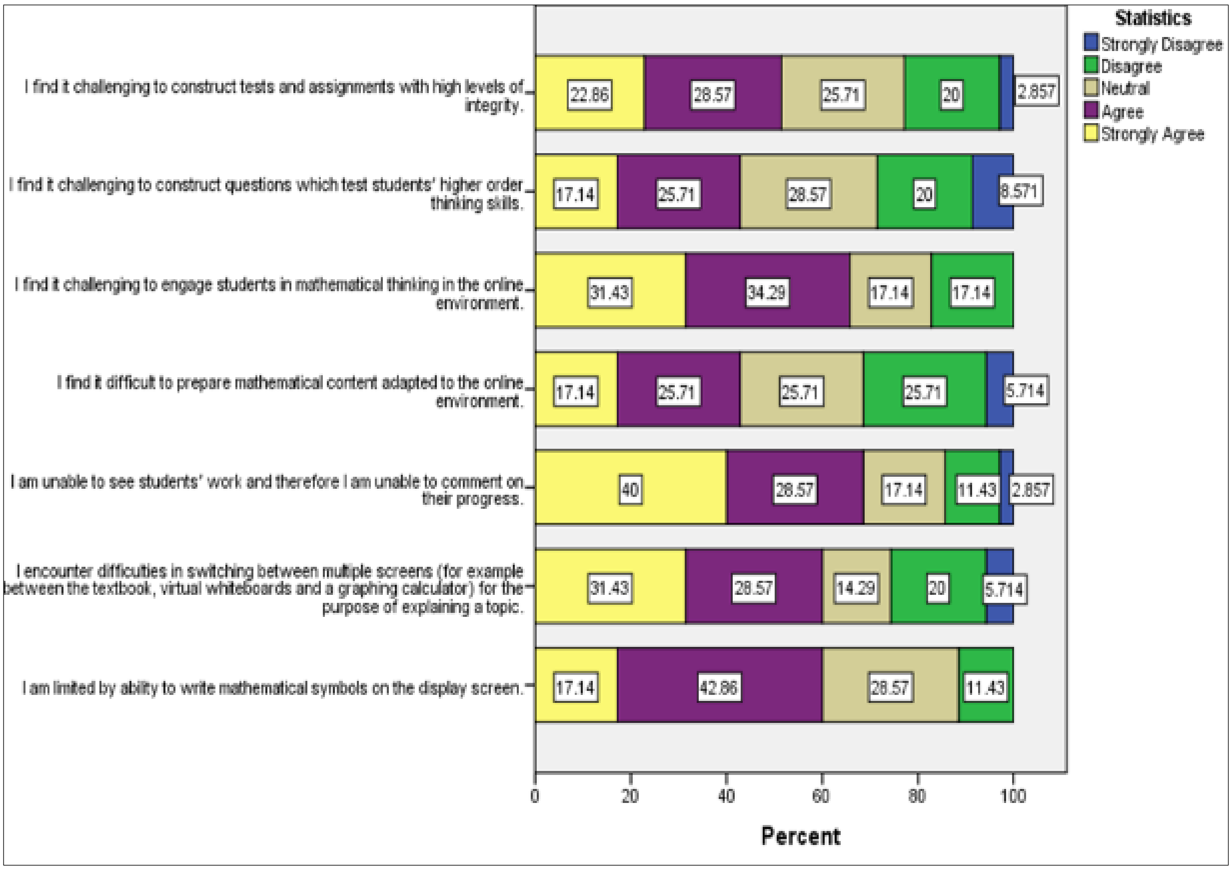

Figure 1 Challenges of Delivering Mathematics in the Online Environment

Table 3 and the stacked bar graph (Figure 1) above show that 6 (17.14%) respondents strongly agreed with the statement "I am limited by my ability to write mathematical symbols on the screen". A further 15 (42.86%) respondents agreed with the statement while 10 (28.57%) respondents had a neutral view. A total of 4 (11.43%) respondents disagreed with the statement. No respondent strongly disagreed with the statement.

On Table 3 and the stacked bar graph (Figure 1) above revealed that 14 (40%) respondents strongly agreed with the statement "I am unable to see students' work and therefore I am unable to comment on their progress" and another 10 (28.57%) respondents agreed with the statement. A total of 6(17.14%) respondents had a neutral view, 4 (11.43%) disagreed and only 1 (2.86%) strongly disagreed.

Further, Table 3 and Figure 1 (stacked bar graph) further revealed that 11 (31.43%) respondents strongly agreed with the statement "I encounter difficulties in switching between multiple screens" and 10 (28.57%) respondents agreed with the statement. A further 5 (14.29%) respondents had a neutral view, 7 (20%) disagreed and 2 (5.71%) strongly disagreed.

When given the statement "I find it difficult to prepare mathematical content adapted to the online environment", a total of 6 (17.14%) respondents strongly agreed and 9 (25.71%) respondents agreed, another 9 (25.71%) respondents had a neutral view and a further 9 (25.71%) respondents disagreed. 2 (5.71%) respondents strongly disagreed with this statement (Table 3 and Figure 1).

As it relates to the statement "I find it challenging to engage students in mathematical thinking in the online environment", 11 (31.43%) respondents strongly agreed and 12 (34.29%) respondents agreed. 6 (17.14%) had a neutral view and another 6 (17.14%) disagreed while no respondent strongly disagreed with the statement (Table 3 and Figure 1).

A total of 6 (17.14%) respondents strongly agreed with the statement "I find it challenging to construct questions that test students' higher-order thinking skills". 9 (25.71%) respondents agreed with the statement and 10 (28.57%) had a neutral view. A total of 7 (20%) respondents disagreed and 3 (8.57%) strongly disagreed (Table 3 and Figure 1).

The final statement intended to measure challenges was "I find it challenging to construct tests and assignments with a high level of integrity". A total of 8 (22.86%) and 10 (28.57%) participants strongly agreed and agreed respectively. 9 (25.71%) participants had a neutral view. 7 (20%) participants disagreed with the statement and only 1 (2.86%) participant strongly disagreed (Table 3 and Figure 1).

The distribution of responses for each statement was found to be similar, with a moderate percentage of respondents either strongly agreed or agreed with the statements. This percentage ranges from 42.85% to 68.57% (or between 15 and 24 respondents). While this range appears to cover around only half of the respondents' views, many respondents exercised their discretion to have a neutral view on the statements (between 14.29% and 28.57% or between 5 and 10 respondents). Therefore, this leaves the number of participants who either disagreed or strongly disagreed with the statements between 4 (11.43%) and 11 (31.42%). This result is in the affirmative that respondents do believe that there are challenges to teaching mathematics in the online environment (Figure 1).

One of the primary challenges in online mathematics education is technological accessibility. Denbel (2023) explored the difficulties faced by postgraduate mathematics students learning through online platforms and found that inadequate internet access and insufficient digital infrastructure hinder effective learning. Similarly, a study by the National Center for Education Statistics (2017) reported that students from low-income backgrounds often lack access to digital learning resources, resulting in an educational gap that disproportionately affects their performance in mathematics.

Abidin *et al*. (2016) highlight that while mobile learning offers opportunities to enhance mathematical literacy, its implementation faces challenges related to equity and access. In regions like Indonesia, disparities in access to technology and the internet can exacerbate existing educational inequalities, making it difficult for all students to benefit equally from online mathematics instruction. Institutional policies can either facilitate or hinder the effective delivery of online mathematics education. Abidin *et al*. (2016) emphasizes that in some educational settings, policies may restrict the use of mobile devices due to concerns over inappropriate use, limiting the potential benefits of mobile learning for mathematics education. Supportive policies and infrastructure are essential to address these challenges effectively.

A study by Mogavi *et al.* (2021) identifies technological issues as a primary barrier to active learning in synchronous online mathematics classes. Students often face challenges such as unstable internet connections, inadequate hardware, and difficulties navigating online platforms. These obstacles can disrupt the learning process, leading to frustration and decreased engagement. The shift to online learning has implications for the mental health and well-being of both students and teachers. Mogavi *et al*. (2021) discuss how the isolation inherent in online learning environments can lead to feelings of disconnection and stress among students, potentially impacting their academic performance and overall well-being.

Trenholm (2023) emphasizes that fully online mathematics education often lacks the immediate, synchronous interactions vital for developing mathematical thinking. The asynchronous nature of many online platforms can lead to delays in feedback, hindering the reflective and communicative processes essential for learning mathematics. Additionally, the absence of non-verbal cues, such as gestures and facial expressions, limits the richness of mathematical discourse, making it challenging for educators to gauge student comprehension in real-time.

Mathematics is a subject that requires active engagement and immediate feedback, which is often limited in an online setting. Mathews *et al.* (2022) examined the effectiveness of interactive digital tools in maintaining student engagement and found that while some virtual platforms helped, they could not fully replicate the interactive nature of traditional classroom settings. Dana-Picard (2023) highlighted that automated feedback systems could not entirely replace personalized teacher-student interactions, leading to decreased motivation and comprehension among students.

Effective assessment in mathematics requires a blend of formative and summative evaluation methods, which are challenging to implement in an online environment. Simonetti *et al.* (2021) discussed how online assessments often fail to accurately measure student understanding due to difficulties in preventing academic dishonesty and ensuring conceptual comprehension. The study also noted that multiple-choice formats, commonly used in online assessments, are inadequate for evaluating complex problem-solving skills.

The hierarchical nature of mathematics learning, where new concepts build upon prior knowledge, presents another challenge in online instruction. Senyefia (2017) found that students who struggled with foundational concepts found it harder to progress in an online environment compared to traditional classrooms. The study emphasized the need for structured, adaptive learning pathways to address individual learning gaps effectively. Tayfour and Alibraheim (2025) reinforced this finding, noting that virtual labs provided some relief but lacked the dynamic adaptability of in-person instruction.

Plana and Ybanez (2023) explored the experiences of mathematics teachers transitioning to online instruction. Their findings reveal that educators often feel unprepared for the shift, citing a lack of training in online pedagogical strategies. Despite these challenges, many teachers demonstrated adaptability by developing new materials and methods to engage students virtually. However, the initial lack of preparedness highlights the need for comprehensive professional development in online teaching methodologies. The study by Plana and Ybanez (2023) also sheds light on cultural and contextual challenges in online mathematics education. In areas where traditional classroom settings are the norm, both educators and students may face difficulties adapting to online platforms. Cultural attitudes towards technology in education can influence the effectiveness of online learning modalities.

The online environment poses significant challenges for both formative and summative assessments in mathematics. Trenholm (2023) notes that without face-to-face interaction, educators struggle to monitor students' developing understanding through traditional means. The reliance on computer-based assessments often focuses on final answers rather than the problem-solving process, providing a limited view of student learning. Moreover, ensuring academic integrity during online assessments remains a persistent concern. The online learning environment can impact student motivation and engagement negatively.

Trenholm (2023) discusses how the screen-based medium may cue students to relax their mental engagement, making it more difficult to achieve the high-level cognitive processing necessary for deep learning in mathematics. Additionally, the potential for multitasking and external distractions in a home environment can further detract from focused study. Developing effective online mathematics resources requires significant time and expertise. Trenholm (2023) points out that educators often need to create new materials suitable for online delivery, which can be a daunting task without adequate support. Ensuring that these resources are engaging and pedagogically sound is crucial for student success.

Yue *et al*. (2024) examined the impact of online learning on students' cognitive load and found that the lack of face-to-face interaction led to increased feelings of isolation, frustration, and decreased motivation. Salami and Spangenberg (2024) observed that students were less likely to seek help in virtual environments, further exacerbating difficulties in mastering complex mathematical concepts.

Table 4 Opportunities of Delivering Mathematics in the Online Environment

Opportunities	**Response options**				
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
I believe that the use of mathematical software (simulators, graphing calculators, etc.) enhances students understanding of the concepts.	16	11	7	1	0
I believe that hardware/ software technologies that allows mathematical symbols to be easily rendered on screen are necessary for teaching mathematics in the online environment.	20	15	0	0	0
I believe that specialized training on how to teach mathematics in the online environment should be provided for mathematics teachers.	27	7	0	0	1
I believe that specialized training on how to construct mathematics questions that test higher order thinking skills in the online environment should be provided for mathematics teacher.	22	10	2	1	0
I believe that specialized training on how to construct mathematics questions with high integrity in the online environment should be provided for mathematics teachers.	24	7	2	2	0
I believe that specialized package (devices and software) should be developed for online mathematics education.	27	6	1	1	0

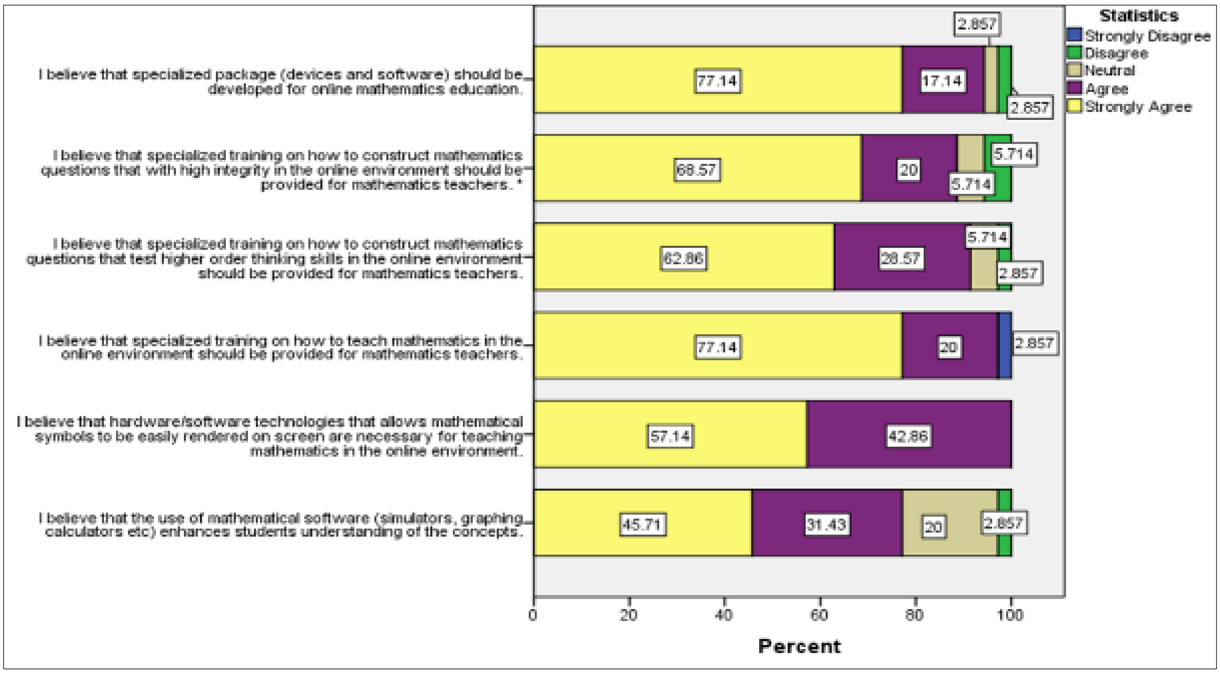

Figure 2 Opportunities of Delivering Mathematics in the Online Environment

Table 4 and stacked bar graph (Figure 2) above show that 16 (45.71%) respondents strongly agreed with the statement "I believe that the use of mathematical software enhances students' understanding of the concepts". A total of 11 (31.43%) respondents agreed with the statement and 7 (20%) had a neutral view. While 1 (2.86%) respondent disagreed with the statement, no respondent strongly disagreed.

Table 4 and Figure 2 (stacked bar graph) also show that in response to the statement "I believe that the use of hardware/software technologies that allow mathematical symbols to be easily rendered on screen are necessary for teaching mathematics in the online environment", 20 (57.14%) respondents strongly agreed with the statement and the remaining 15 (42.86%) respondents agreed with the statement.

In addition, Table 4 and the stacked bar graph (Figure 2) above further revealed that 27 (77.14%) respondents strongly agreed with the statement "I believe that specialized training on how to teach mathematics in the online environment should be provided for mathematics teachers". Another 7 (20%) respondents agreed with the statement and the remaining 1 (2.86%) strongly disagreed.

When given the statement "I believe that specialized training on how to construct mathematics questions that test higher order thinking skills in the online environment should be provided for mathematics teachers", a total of 22 (62.86%) respondents strongly agreed and 10 (28.57%) respondents agreed. 2 (5.71%) respondents had a neutral view and 1 (2.86%) respondent disagreed (Table 4 and Figure 2).

A total of 24 (68.57%) respondents strongly agreed with the statement "I believe that specialized training on how to construct mathematics questions with high integrity in the online environment should be provided for mathematics teachers". 7 (20%) respondents agreed with the statement and 2 (5.71%) respondents had a neutral view and 2 (5.71%) more respondents disagreed (Table 4 and Figure 2).

The final statement intended to measure opportunities was "I believe that specialized package (devices and software) should be developed for online mathematics education". A total of 27 (77.14%) and 6 (17.14%) respondents strongly agreed and agreed respectively. 1 (2.86%) respondent had a neutral view and 1 (2.86%) respondent disagreed (Table 4 and Figure 2).

The distribution of responses for each statement was found to be similar, with most respondents either strongly agreed or agreed with the statements. For each statement, at least 77.14% (27 out of 35 respondents) of respondents either strongly agreed or agreed that there are various opportunities for teaching mathematics in the online environment. Overall, 2 (5.714%) respondents either disagreed or strongly disagreed with the statements. This result is in the affirmative that respondents do believe that six factors highlighted provide opportunities of teaching mathematics in the online environment (Figure 2).

Abidin *et al*. (2016) explored the potential of mobile learning technologies in promoting mathematical literacy. Their study identified that while mobile devices offer flexibility and accessibility, challenges such as ethical concerns and curriculum integration hinder their widespread adoption. Teachers' unfamiliarity with mathematical literacy and apprehensions about mobile device misuse were significant barriers. Abidin *et al*. (2016) also discussed the opportunities and challenges of mobile learning for promoting mathematical literacy. The study highlighted the potential of mobile technologies to enhance learning experiences but noted challenges such as ethical concerns and curriculum integration. Teachers' unfamiliarity with mathematical literacy and apprehensions about mobile device misuse were significant barriers.

A study published in Mathematics (2020) surveyed 257 mathematics lecturers to understand their experiences with emergency remote teaching during the COVID-19 pandemic. Findings indicated that many lecturers found the transition beneficial, gaining experience and resources that could enhance future teaching. However, challenges such as technical issues and the need for professional development were also noted.

Busto *et al*. (2020) presented a blended teaching model for mathematics during the COVID-19 pandemic, combining traditional blackboard lectures with online streaming. This approach maintained the dynamic nature of in-person teaching while accommodating students unable to attend physically. The study emphasized the importance of preserving the interactive and creative aspects of mathematics instruction.

Livya *et al*. (2021) investigated innovative methods employed by mathematics educators to adapt their courses to online formats during the COVID-19 pandemic. The study found that utilizing various technological tools facilitated interactive learning experiences, aligning with the Substitution, Augmentation, Modification, and Redefinition (SAMR) model. This approach allowed for the transformation of traditional teaching methods to suit online environments.

Santos and Costa (2021) examined the implementation of a flipped classroom model for Linear Algebra using a Massive Open Online Course (MOOC) platform. The study found that providing virtual learning content, such as videos and formative assessments, enhanced student engagement and allowed for more interactive in-class activities.

Salifu and Owusu-Boateng (2022) evaluated the media platforms and devices used for online mathematics teaching during the COVID-19 pandemic. Platforms like Zoom, Telegram, WhatsApp, and Google Classroom were commonly used, with smartphones being the most prevalent device. Challenges identified included high internet costs, lack of access to smart devices, and poor internet connectivity, particularly in remote areas.

Tezer and Gülyaz (2022) examined university students' perspectives on using mobile learning technologies in online mathematics courses during the pandemic. The study revealed that students engaged with mobile tools to enhance their understanding and believed these technologies facilitated easier access to learning materials. Challenges included inadequate technical infrastructure and distractions associated with mobile device use.

An article published in Digital Experiences in Mathematics Education (2023) analyzed the affordances of virtual learning environments (VLEs) in supporting mathematics teaching. The study highlighted that platform like STEP, DESMOS, WIMS, and Labomep offer tools for mathematical communication and data visualization, which can enhance instructional practices. However, effective integration requires teachers to develop specific digital competencies.

Yue *et al*. (2024) introduced MathVC, an LLM-powered virtual classroom designed to simulate multi-character interactions for collaborative problem-solving in mathematics. This platform enables students to engage in group discussions and practice mathematical modeling skills, addressing the scarcity of resources and uneven teacher distribution in traditional settings.

4. Conclusion

The results of this study revealed that secondary school teachers and lecturers in Region 6 face several challenges in teaching mathematics when utilizing the online environment and these challenges are consistent and in tandem with those identified in the literature. Approximately half of the respondents agreed to have faced the challenges of being able to write mathematical symbols on the screen, switching between multiple screens, seeing and commenting on student's work, preparing mathematical content for online learning, engaging students in mathematical thinking, constructing higher order questions and set tests with high levels of integrity. The challenge agreed on by most educators is the difficulty to engage students in mathematical thinking in the online environment and the challenge most disagreed on is that they found it difficult to prepare mathematical content adapted to the online environment. At least three-quarters of the respondents agreed that opportunities for improving online mathematics education exist. These opportunities range from being able to use specialized mathematical hardware and software to the provision of specialized training on how to teach online mathematics as well as how to construct questions for online mathematics. All of the respondents agreed that the use of hardware/software technologies that allow mathematical symbols to be easily rendered on screen is necessary for teaching mathematics in the online environment. The least agreed upon opportunity is that the use of mathematical software enhances students' understanding of the concepts.

Limitation and Recommendations

The Ministry of Education (MOE) should provide a specialized package for online mathematics educators. This specialized package includes the hardware/software designed for the teaching of online mathematics as well as the necessary training to teach online mathematics. This pilot should be extended to a larger region of Guyana. Further, the distribution of the sample size of the number of lecturers to the number of secondary educators were uneven which can contribute to the current results of this study. More mathematics lecturers from tertiary and technical institutions around the country should be encouraged and given the opportunity to participate in studies of this magnitude. The results and findings of those studies can then be compared to other studies to assess if all the studies draw the same conclusion.

Compliance with ethical standards

Acknowledgments

The authors would like to thank the University of Guyana, Faculty of Natural Sciences, Department of Biology, Faculty of Education and Humanities, Department of Curriculum and Instruction and the College of Medical Sciences for giving this tremendous opportunity and supporting the successful completion of this research.

Disclosure of conflict of interest

The authors certify that thus submission is original work and is not under review at any other publication. The authors hereby declare that this manuscript does not have any conflict of interest.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study. All work utilized in this study was fully cited and referenced so all authors of prior researches are given their due credentials for their work.

References

[1] Abidin Z, Mathrani A, Parsons D, Suriadi S. Opportunities and challenges of mobile learning for promoting mathematical literacy. Journal of Educational Technology & Society. 2016;19(2):151-163.

[2] Adler J, Davis Z. Opening another black box: Researching mathematics for teaching in mathematics teacher education. J Res Math Educ. 2006;37(4):270–96. https://doi.org/10.2307/30034851.

[3] Agyei E, Agyei DD, Benning I. Teaching mathematics with digital technologies: A situational analysis of high school teachers'. Educational Technology Quarterly. 2024;31(2):75–92. https://acnsci.org/journal/index.php/etq/article/view/874.

[4] Baker R, Myers J, Collins D. Equity and Access in Online Mathematics Education: Overcoming Technological Barriers. International Journal of Education and Development. 2020;44(3):99-115.

[5] Ball DL, Bass H. Toward a practice-based theory of mathematical knowledge for teaching. In: Davis B, Simmt E, editors. Proceedings of the 2002 annual meeting of the Canadian Mathematics Education Study Group. CMESG/GDEDM; 2003. p. 3–14. https://files.eric.ed.gov/fulltext/ED529557.pdf.

[6] Breslich E. Importance of mathematics in general education. Math Teach. 1966;59(5):464–9. http://www.jstor.org/stable/27957386.

[7] Busto S, Dumbser M, Gaburro E. A simple but efficient concept of blended teaching of mathematics for engineering students during the COVID-19 pandemic. arXiv preprint arXiv:2010.14247. 2020.

[8] Cassibba R, Ferrarello D, Mammana MF, Musso P, Pennisi M, Taranto E. Teaching mathematics at distance: A challenge for universities. Educ Sci. 2021;11(1):1. https://dx.doi.org/10.3390/educsci11010001.

[9] Dana-Picard T. Computer-assisted proofs and automated methods in mathematics education. arXiv preprint arXiv:2303.10166. 2023. https://arxiv.org/abs/2303.10166.

[10] Denbel DG. Challenges of Teaching and Learning Mathematics Courses in Online Platforms. Int J Online Pedagog Course Des. 2023;13(1):1-14.

[11] Digital Experiences in Mathematics Education. Exploring the potential of virtual learning environments (VLEs) in mathematics teaching. Digital Experiences in Mathematics Education. 2023 Mar. https://link.springer.com/article/10.1007/s40751-023-00127-4.

[12] Fabito BS, Trillanes AO, Sarmiento JR. Barriers and challenges of computing students in an online learning environment: Insights from one private university in the Philippines. arXiv preprint arXiv:2012.02121. 2020.

[13] Gadanadis G, Graham L, McDougall D, Roulet G. Online mathematics: Visions and opportunities, issues and challenges, and recommendations. Fields Inst Res Math Sci. 2002. http://www.fields.utoronto.ca/programs/mathed/02-03/online/onlinereport.pdf.

[14] Greene K. Evidence-based math instruction: What you need to know. Understood [Internet]. 2021. Available from: https://www.understood.org/en/school-learning/for-educators/teaching-strategies/evidence-based-math-instruction-for-struggling-students.

[15] Huang D, Manouchehri A. Online mathematics teacher education in the US: A status report. Contemp Issues Technol Teach Educ. 2019;19(2):171–94.

[16] Irfan M, Kusumaningrum B, Yulia Y, Widodo S. Challenges during the pandemic: Use of e-learning in mathematics learning in higher education. J Math Educ. 2020;9(2):147–58. https://www.researchgate.net/publication/345846956_CHALLENGES_DURING_THE_PANDEMIC_USE_OF_E-LEARNING_IN_MATHEMATICS_LEARNING_IN_HIGHER_EDUCATION.

[17] Karadimitriou S, Marshall E. StatsTutor community project [Internet]. 2015. Available from: https://www.sheffield.ac.uk/polopoly_fs/1.885094!/file/58_ChiSquare.pdf.

[18] Keegan D. Theoretical principles of distance education. New York: Routledge; 1993.

[19] Livya I, Kumar S, Ravi S. Creative approaches to online mathematics education during the COVID-19 pandemic. International Journal of Mathematical Education in Science and Technology. 2021. tandfonline.com.

[20] Maki RH, Maki WS, Patterson M, Whittaker PD. Evaluation of a web-based introductory psychology course: I. Learning and satisfaction in online versus lecture courses. Behav Res Methods Instrum Comput. 2000;32(2):230–9.

[21] Mathematics. Experiences of mathematics lecturers in emergency remote teaching during COVID-19: An exploratory survey. Mathematics. 2020. mdpi.com.

[22] Mathews A, Rao A, Kumar S. VedicViz: Visualizing Vedic principles in mental arithmetic. arXiv preprint arXiv:2205.08845. 2022. https://arxiv.org/abs/2205.08845.

[23] Mogavi RH, Zhao Y, Haq EU, Hui P, Ma X. Student Barriers to Active Learning in Synchronous Online Classes: Characterization, Reflections, and Suggestions. Journal of Online Learning Research. 2021;7(1):35-52.

[24] National Center for Education Statistics. Challenges faced by students who lack access to digital learning resources. NCES Report. 2017.

[25] Ni A. Comparing the effectiveness of classroom and online learning: Teaching research methods. J Public Aff Educ. 2013;19(2):199–215. http://www.jstor.org/stable/23608947.

[26] Nomann-Loomis D. The challenges of online math instruction. eSchool News [Internet]. 2020. Available from: https://www.eschoolnews.com/2020/10/16/challenges-online-math-instruction/.

[27] Paterson R, Noble M. Reframing Online Learning in Mathematics: Pedagogical Adjustments in the Digital Classroom. Journal of Education Research and Practice. 2022;43(1):56-71.

[28] Plana SC, Ybanez EB. Challenges Encountered by Mathematics Teachers Through Online Learning. Industry and Academic Research Review. 2023;4(1):431-437.

[29] Radmehr F, Goodchild S. View of online mathematics teaching and learning during the COVID-19 pandemic: The perspective of lecturers and students. Nord J STEM Educ. 2021;5(1):1–14. https://www.ntnu.no/ojs/index.php/njse/article/view/3914/3634.

[30] Salami A, Spangenberg H. Assessing the role of online mathematics tools in enhancing student learning and engagement. Educational Technology Quarterly. 2024;31(2):75–92. https://acnsci.org/journal/index.php/etq/article/view/874.

[31] Salifu M, Owusu-Boateng N. Evaluating online teaching platforms and challenges for mathematics education during the COVID-19 pandemic in Ghana. African Journal of Online Mathematics Education. 2022. journalarjom.com.

[32] Santos AM, Costa L. Flipping Linear Algebra using a MOOC platform. arXiv preprint arXiv:2103.11810. 2021.

[33] Sinclair N, Crespo S. Learning mathematics in dynamic computer environments. Teach Child Math. 2006;12(9):436–44. https://www.jstor.org/stable/41198823.

[34] Stack S. Learning outcomes in an online vs traditional course. Int J Scholarsh Teach Learn. 2015;9(1):Art. 5. https://digitalcommons.georgiasouthern.edu/cgi/viewcontent.cgi?article=1491&context=ij-sotl.

[35] Senyefia A. Effect of physical and virtual manipulatives on junior high school students' achievement in geometry. Asian Research Journal of Mathematics. 2017;5(4):1–12. https://journalarjom.com/index.php/ARJOM/article/view/137.

[36] Simonetti G, Repetto C, Riva G. Teaching math with the help of virtual reality: Enhancing comprehension through immersion. arXiv preprint arXiv:2111.01973. 2021. https://arxiv.org/abs/2111.01973.

[37] Swan K, Shea P, Frederickson E, Pickett A, Pelz W, Maher G. Building knowledge-building communities: Consistency, contact, and communication in the virtual classroom. J Educ Comput Res. 2000;23(4):389–413.

[38] Tayfour M, Alibraheim M. Revolutionizing elementary mathematics education through virtual labs. International Electronic Journal of Elementary Education. 2025;17(1):45-67. https://www.iejee.com/index.php/IEJEE/article/view/2218.

[39] Tezer F, Gülyaz S. Mobile learning technologies in online mathematics courses during the pandemic: A student perspective. International Journal of Interactive Mobile Technologies. 2022. online-journals.org.

[40] The Times. Estonia's curriculum is one of the best—what can it teach us? The Times. 2024. https://www.thetimes.co.uk/article/estonias-curriculum-is-one-of-the-best-what-can-it-teach-us-l56hmdxq0.

[41] Trenholm S. Challenges and suggestions regarding the aesthetic experience of mathematics when teaching and learning fully online. Journal of Mathematics Education. 2023;12(2):45-60.

[42] Trenholm S. Mathematical Thinking in Online Spaces: Addressing the Challenges of Virtual Learning in Higher Education. Mathematics Education Review. 2023;18(2):81-95.

[43] Werhner M. A comparison of the performance of online versus traditional on-campus learning. J Instr Pedagog. 2010;3:1–9. https://files.eric.ed.gov/fulltext/EJ1164616.pdf.

[44] White C, Lin K, Wong J, Huang W. The impact of asynchronous learning on the teaching and learning of mathematics in online platforms. Educational Technology and Society. 2021;24(4):12-24.

[45] Wired. Generative AI in mathematics homework assistance. Wired. 2024. https://www.wired.com/story/gauth-ai-math-homework-app.

[46] Yue Y, Wang L, Zhou X. MathVC: An LLM-simulated multi-character virtual classroom for mathematics education. arXiv preprint arXiv:2404.06711. 2024. https://arxiv.org/abs/2404.06711.