

**A COMPARATIVE REVIEW OF ONLINE AND IN-PERSON MATHEMATICS INSTRUCTION:  
EFFECTIVENESS, CHALLENGES, AND INFLUENCING FACTORS**PTN Devindi<sup>1</sup>**Abstract**

This comparative review explores the effectiveness of online versus in-person mathematics instruction, focusing on key factors that influence student learning outcomes. As education shifted to digital platforms, particularly during the COVID-19 pandemic, new opportunities and challenges arose—especially in a cognitively demanding subject like mathematics. Emotional factors such as anxiety, stress, and external problems have significantly hindered students' engagement and focus. In parallel, the lack of a supportive home environment and inconsistent parental involvement have further impacted performance. Technological barriers, including limited internet access and inadequate digital devices, have exposed gaps in digital equity, affecting participation and continuity in learning. Furthermore, reduced teacher-student interaction in virtual settings has made personalized feedback and conceptual teaching more difficult, while online learning fatigue and reduced motivation have contributed to lower student satisfaction and achievement. While online learning provides flexibility, this review highlights the pressing need for enhanced instructional strategies, improved infrastructure, and greater attention to students' emotional and motivational needs. Addressing these challenges is crucial for ensuring effective mathematics education in both virtual and traditional learning platforms. This review selected peer-reviewed literature in English focusing on school-level mathematics education in online and in-person settings, particularly in contexts similar to Sri Lanka, with emphasis on studies addressing learning outcomes, emotional and motivational challenges, digital equity, and instructional effectiveness.

**Keywords:** Digital equity, Instructional challenges, Mathematics Education, Online learning, Student engagement.

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## **Introduction**

The rapid transformation of online learning, primarily brought on by the pandemic, has altered educational practices around the world. This change has led to greater flexibility and accessibility, but it has also brought about many challenges, particularly in subjects like mathematics that require a high level of conceptual understanding, engagement, and interactive support,

Real-time feedback, structured classroom interactions, and hands-on experiences are all components of traditional mathematics teaching methods that are commonly jeopardized in virtual environments. This has resulted in different learning outcomes since many students have struggled to adapt to online learning environments. This issue has become increasingly complicated by emotional elements like stress and anxiety, technological obstacles, decreased teacher-student interaction, and a lack of support at home.

Exploring the elements that affect students' performance in online mathematics learning is essential given the significance of mathematics in both academic and practical contexts. In order to provide insights that can guide better teaching practices and regulations for upcoming online education models, this study compares and examines the major factors that influence learning outcomes in this context.

Moreover, as the transformation of online learning continues to evolve, it is crucial to assess not only the cognitive but also the socio-emotional dimensions that contribute to student success in mathematics. Factors such as learner autonomy, digital literacy, and motivation play an important role in determining how effectively students engage with mathematical content in a virtual setting. Differences in access to reliable technology, varying levels of parental involvement, and disparities in teacher preparedness for online instruction further widen the gap in educational equity. By critically analyzing these interconnected factors, this review aims to offer a comprehensive understanding of how learning environments impact mathematics education and to emphasize strategies that can bridge the gap between traditional and digital instruction.

## **Theoretical Framework**

The comparison between online and in-person mathematics instruction is grounded in several well-established learning theories that help explain how students acquire, process, and retain mathematical knowledge in different environments.

### **Constructivist Learning Theory**

Rooted in the work of Piaget and Vygotsky, constructivism emphasizes that learners actively build their understanding through experiences and interactions. This theory comes to life through classroom discussions, hands-on problem-solving, and peer collaboration. In online environments, constructivist principles are reflected through interactive tools, virtual simulations, and forums that allow students to explore and construct knowledge independently or collaboratively. (Hein, 1991)

### **Cognitive Load Theory**

Developed by John Sweller, this theory posits that learning is affected by the amount of mental effort required to process information. In mathematics instruction, managing cognitive load is crucial due to the abstract and sequential nature of the subject. In-person instruction typically supports learners with immediate feedback and guided practice, helping manage cognitive load more effectively. Online instruction must be carefully designed to avoid overwhelming students with complex interfaces or excessive self-navigation. (Sweller, 2011)

### **Behaviorist Theory**

Based on the findings of B.F. Skinner, behaviorism focuses on observable behaviors and the use of reinforcement to shape learning. This theory underpins practices such as drill-and-practice exercises, quizzes, and immediate feedback—common in both online and in-person mathematics instruction. Online platforms often implement behaviorist strategies through gamified learning and instant feedback mechanisms to maintain engagement. (Demirezen, (1988))

### **Community of Inquiry (CoI) Framework**

Particularly relevant to online learning, this model focuses on three core elements: cognitive presence (critical thinking), social presence (interaction and collaboration), and teaching presence (instructional design and facilitation). Mathematics learning in an online context benefit from a strong teaching presence and well-structured interactions that help students feel supported and engaged. Together, these theoretical perspectives provide a foundation for analyzing the strengths and limitations of online and face-to-face instruction. They help explain why certain approaches may be more effective depending on the learning environment, and they guide

the interpretation of findings in this comparative review. (Arbaugh, J. B., Bangert, A., & Cleveland-Innes, M., , 2010)

**Comparative Studies on Online vs. In-Person Mathematics Learning**

It is important to recognize that both online and in-person learning environments offer unique advantages and limitations, especially in the context of mathematics education. While traditional classrooms provide structure, direct or in-person interaction, and immediate feedback, online platforms offer flexibility and accessibility. The following table highlights the key differences between the two modes of instruction, focusing on how they influence student engagement, instructional quality, and learning outcomes.

**Table 01: Comparative Studies on Online vs. In-Person Mathematics Learning**

Aspect	Online Instruction	In-Person Instruction
Teaching presence	Heavily depends on course design and platform; and can be weak without active facilitation (Garrison et al., 2000).	Physical presence and immediate support from the teacher.
Student Engagement	Lack of peer interaction (Mulqueeny, K., Kostyuk, V., Baker, R. S., & Ocumpaugh, J., 2015)	Enhanced through peer discussions, group activities, and real-time feedback. (Demirezen, (1988))
Assessment Methods	A majority of the assignments are structured as multiple-choice questions, which are commonly used in online assessments. Once students submit their quizzes, the system automatically generates grades, providing immediate access to their results and corrections. This process has been shown to support effective formative assessment. (Joglar, N., Martín, D., Colmenar, J. M., Martínez, I., & Hidalgo, J. I., 2010)	In in-person classrooms, assignments often include written problem-solving tasks, allowing teachers to assess students' reasoning processes and provide immediate feedback.
Accessibility	Dependent on internet access and devices. (Casinillo, L. F., Casinillo, E. L., Valenzona, J. V., Almonite, M. R. C., & Valenzona, D. L., 2022)	Requires physical attendance but less impacted by technology gaps.

**Key Factors Affecting Online Mathematics Learning Outcomes**

The transformation from in-person to online learning has significantly impacted how students engage with and perform in mathematics. While online education offers flexibility and accessibility, several key factors influence the effectiveness of learning outcomes, particularly in subjects like mathematics that require conceptual understanding and problem-solving skills. Understanding these factors plays a pivotal role in improving online mathematics education. Emotional aspects such as stress and anxiety, technological challenges, lack of in-person support, and decreased teacher-student interaction all play vital roles in shaping student performance. This section explores these important factors, providing insight into how they affect learning and offering potential strategies to address them for better outcomes in online mathematics classrooms.

1. **Emotional Factors:**

According to a study by Casinillo et al., the anxiety and stress caused by the COVID-19 pandemic had a significant negative impact on students' ability to focus on learning mathematics. Additionally, distractions such as social media further reduce concentration on mathematical online learning. Ekowati (2019) also highlights that inner conditions play a crucial role in online mathematics learning. In that study, 16 variables were identified as allegedly influencing students' learning outcomes; one of them was the mood of the students. In summary, the combination of anxiety, external distractions, and mood fluctuations significantly hindered students' focus and performance in mathematics during online learning.

2. **Home-Based Learning Support:**

During online mathematics learning, a lack of parental supervision and support was observed by Yohannes et al. (2021). Many parents were busy with work responsibilities, making it difficult for them to guide or monitor their children's learning process at home. Ekowati (2019) further emphasizes the role of the family relationship and residential atmosphere in shaping students' learning experiences. A supportive and peaceful home environment can encourage focus and motivation, whereas a tense or disorganized household may lead to stress and distractions, negatively impacting learning outcomes. The study of Ruiz-Palmero et al., also revealed that factors such as the parents' educational level and the nurturing quality of the family environment play a significant role in shaping a child's development and academic success in online mathematics learning.

### Challenges of Online Mathematics Instruction

Despite its benefits, online mathematics instruction presents several challenges:

- **Technology Barriers:**

Many students faced significant technology barriers during the COVID-19 pandemic, primarily due to the financial crisis. According to Casinillo et al., many students struggled to afford internet access and digital devices, which hindered their ability to participate in online learning. Internet connection can be identified as one of the most significant factors affecting students' ability to learn mathematics online effectively. Putri et al. (2024) highlighted that internet connectivity plays a major role in online mathematics learning.

Furthermore, Ruiz-Palmero et al. (2023) revealed that the type of device students used significantly impacted their performance and perception of online learning. In conclusion, the financial burden of affording internet data and technological devices posed a significant barrier to many students, especially in subjects like mathematics that require active participation and engagement with digital platforms. These technological barriers highlight the need for greater investment in affordable internet access and modern learning devices to ensure equitable learning opportunities for all students.

- **Reduced Teacher-Student Interaction:**

One of the significant challenges in online mathematics learning is the reduced teacher-student interaction, which negatively impacts the quality of education. Yohannes (2021) highlighted that teacher faced difficulties interacting with students in a virtual environment, as face-to-face communication was no longer possible. This lack of interaction made it harder for teachers to understand the individual needs and concerns of students, which in turn affected the overall learning experience. Without the opportunity for real-time feedback and personalized guidance, students failed to fully grasp the lessons.

Moreover, teachers also struggled with providing and managing feedback effectively in an online setting.

Additionally, the shift to online learning required teachers to adapt their teaching strategies. Bin Othman (2023) discussed requiring teachers to develop strategies that engage students virtually. The challenge was not only in the technology but also in adjusting teaching approaches that maintained student engagement and fostered effective learning in a virtual environment.

- **Difficulty in Conceptual Teaching:**

Difficulty in understanding mathematics lessons due to remote instruction emerged as a significant challenge. According to Casinillo et al. (2021), students struggled to comprehend lessons effectively because remote instruction lacked the dynamic and interactive nature of face-to-face teaching. Furthermore, struggles with teaching and understanding content via online platforms were highlighted by Yohannes (2021). Teachers found it challenging to deliver content in an online format, which required adaptations of traditional teaching methods. The limitations of technology and the lack of direct interaction made it difficult for many students to understand the mathematical concepts fully. Additionally, Ruiz-Palmero et al. (2023) pointed out that the focus of the study on mathematics—often considered a challenging subject associated with negative attitudes and learning difficulties—might have impacted the results. The complexity of mathematical content, when combined with the limitations of online learning, made it even more difficult for students to engage in the subject. These challenges, coupled with the perceived difficulty of mathematics, created an environment where students were more likely to struggle with both understanding and staying motivated. In conclusion, the transition to online learning posed significant barriers for students trying to understand mathematical concepts. The limitations of remote instruction, along with the inherent challenges of teaching and learning

mathematics, highlighted the need for innovative approaches and tools to improve the effectiveness of online mathematics education.

- **Decreased Engagement and Motivation:**

Online Learning Fatigue emerged as a significant challenge for students during the online sessions, with prolonged exposure to virtual learning environments leading to decreased satisfaction with technology use. According to Ruiz-Palmero et al. (2023), students' satisfaction with online learning platforms decreased over time. The initial novelty of online learning quickly wore off, and the constant use of technology contributed to fatigue. This fatigue, compounded by the repetitive nature of online sessions and increased screen time, led to diminished engagement and overall dissatisfaction.

This fatigue was further exacerbated by low motivation, as students began perceiving online learning as less effective than traditional face-to-face interactions. Yohannes (2021) revealed that students struggled to maintain interest and enthusiasm in their studies. The perception that online learning was not as effective as in-person learning created frustration and disengagement. This decline in motivation and satisfaction negatively impacted students' academic performance, especially in subjects like mathematics, which require active participation and interaction. These findings highlight the importance of designing more interactive and stimulating virtual learning experiences. Without intentional engagement strategies, online learning may continue to fall short in sustaining student interest, particularly in demanding subjects like mathematics.

## Conclusion

Moving to online learning, particularly for mathematics education, presents challenges and opportunities. Through this comparative study, several key factors affecting online mathematics learning outcomes have been identified.

Firstly, emotional factors such as anxiety, stress, and external distractions have significantly impacted students' ability to focus and engage with the subject. Additionally, the lack of home-based support and varying levels of parental involvement have compounded these challenges. A supportive home environment is crucial for student motivation and performance.

Moreover, technology barriers, including inadequate internet access and limited digital devices, have hindered students' ability of online learning. These barriers highlight the importance of addressing digital equity, ensuring that all students have the tools necessary for success in online learning environments.

Another notable challenge is the reduction in teacher-student interaction. The absence of face-to-face communication has made it harder for teachers to offer personalized attention and feedback, which is critical in a subject like mathematics. This limitation has also led to difficulties in conceptual teaching, with students struggling to understand complex mathematical concepts without the dynamic and interactive support that traditional classroom settings provide.

Finally, online learning fatigue and decreased motivation have emerged as significant obstacles. The repetitive nature of virtual sessions has further worsened these issues, leading to a decline in both student satisfaction and academic performance.

Moreover, the shift to online learning has emphasized the necessity for a more personalized and adaptable approach to teaching mathematics. In traditional classroom settings, teachers can quickly identify the student through non-verbal cues and in-the-moment interaction, allowing for immediate response. Online platforms, however, lack this direct feedback, making it difficult for educators to address individual learning needs in real-time. This limitation underscores the importance of integrating more interactive and adaptive learning technologies in the online environment. For instance, incorporating artificial intelligence-driven tools, automated assessments, and real-time data analytics can help bridge the gap in teacher-student interaction. Such tools can provide immediate feedback, track student progress, and offer tailored learning experiences to address individual challenges in mathematics. Additionally, fostering a sense of community and peer support in virtual learning spaces can mitigate feelings of isolation and help maintain motivation, ultimately enhancing student engagement and learning outcomes in online mathematics education.

In conclusion, while online mathematics education offers flexibility and accessibility, it also introduces significant challenges that must be addressed. To improve learning outcomes, it is essential to develop innovative approaches, invest in digital infrastructure, and enhance teacher training to adapt teaching methods for the online environment. Understanding and addressing the emotional, technological, and motivational barriers to online learning will be

key to ensuring its success, especially in subjects like mathematics that require high levels of engagement and conceptual understanding.

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