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Math lessons go online: Insights and challenges of blended learning during the pandemic

Ming Yan Tsui*, Ida Ah Chee Mok

Department of Mathematics, Science, and Technology, The University of Hong Kong, Pok Fu Lam, Hong Kong
*Correspondence: ivanmyhk@gmail.com

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Abstract

Online learning became a necessity in many places during the COVID-19 pandemic. In the case of Hong Kong SAR, the pandemic provided a unique opportunity to establish blended learning as a norm. The authors discuss the insights and challenges related to delivering mathematics lessons online in a secondary school during and after the pandemic. A three-year-long case study was conducted to examine the differences in perceptions between a teacher and his five students regarding online mathematics instruction during the suspension of traditional in-class lessons in 2020 and after the resumption of traditional instruction in 2023. The Social-Ecological Approach with domains of structure, agency, and cultural practice was applied in the study, which investigated the perceived benefits of blended learning for both the students and the teachers. Data was collected via interviews. The study explored technological challenges, curriculum adaptations, and the impact of parental support on blended learning. Looking ahead, leveraging motivators like easy access while mitigating distractors through disciplined strategies can optimize blended learning environments. The insights gained from this study provide valuable guidance on the effectiveness of instructional strategies and technological tools, highlighting the features of best practices for future blended learning approaches. Furthermore, the paper provides valuable information for policymakers, educators, and educational technology developers.

Keywords: Blended Learning, Mathematics, Pandemic, Secondary School

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Blended learning is increasingly recognized as an innovative educational approach that seamlessly integrates traditional in-class instruction with online learning components. This method accommodates diverse learning styles and preferences that can foster a more inclusive educational environment. According to Mackey (2015), blended learning enhances learning outcomes by capitalizing on the strengths of both in-person interactions and digital resources, thereby highlighting its potential as a transformative pedagogical tool. Although blended learning has several advantages, the findings from most of the empirical studies that have been conducted so far have been based on localized results. As there are a plethora of education systems, implementing this type of program can create a range of unique challenges and concerns, depending on the system's characteristics. Additionally, more studies are needed on the different stakeholders' concerns in implementing blended learning in a school environment. This paper fills this gap by directly investigating the concerns that arose while implementing blended learning at one specific Hong Kong school. Thus far, Hong Kong's secondary education system

has been hesitant to fully embrace blended learning due to inadequate levels of support and training provided to teachers. Blended learning has not been widely adopted among secondary schools in Hong Kong due to limited resources and a lack of technological pedagogical content knowledge (TPACK). This aligns with Li et al. (2022), who proposed that the light workload associated with blended learning encourages teachers to accept its implementation. The lack of professional development opportunities and uncertainty regarding the efficacy of blended learning in the context of secondary education has also contributed to the slow adoption of this approach.

How can these challenges be overcome and converted into opportunities? The onset of the COVID-19 pandemic in 2020 brought about an unexpected shift in the educational landscape, compelling Hong Kong's secondary schools to pivot swiftly to online learning. While this shift posed immense challenges, experiences with prior initiatives such as the Bring Your Own Device (BYOD) scheme and collaborations with technology companies played a pivotal role in facilitating this transition. Corporations like Microsoft, Google, Zoom, and Slack provided devices and essential software that enabled education to continue and exposed educators and students to the potential benefits of using digital tools in learning. Hence, the pandemic presented a unique opportunity for Hong Kong's education sector to reassess its strategies. The accelerated adoption of online learning during the crisis became a catalyst for a broader conversation on the viability and advantages of blended learning. Schools and educational institutions were compelled to reevaluate their teaching methods and explore the untapped potential of educational technology. Therefore, as part of an early effort to evaluate blended learning, a three-year-long longitudinal case study was conducted, utilizing qualitative data, to explore the benefits and challenges associated with implementing blended learning through a BYOD scheme in an authentic Hong Kong school setting. This involved comparing the COVID and post-COVID eras and tracing how the pedagogy of the teacher at the center of the study evolved over time. The teacher was interviewed both during the pandemic and after the resumption of in-class lessons. To enhance the study's validity, two sets of five students were interviewed, one from the pandemic era and the other post-COVID. Likewise, the teaching methods and resources used in their respective classes were thoroughly assessed.

To set this particular case in terms of the broader conversation regarding the development of blended learning, this study draws upon the existing literature on blended learning and the impact of the pandemic on education to inform the research design and data analysis. The findings of this study will contribute to the emerging body of research on blended learning and provide practical recommendations for educators and policymakers seeking to improve the effectiveness of blended learning in the future. Furthermore, by gaining insights into the experiences of those involved in blended learning during the pandemic, this study utilizes the socio-cultural ecological approach (SEA) to explore the implementation of blended learning from the perspectives of agency, cultural practices, and structures. In doing so, the results will be able to inform the development of pedagogical strategies that can better support student learning in the post-pandemic era.

Theoretical Background

Pachler et al. (2010) introduced the Socio-cultural Ecological Approach (SEA) as a framework to study mobile learning, based on the principles of socio-cultural learning theory (Vygotsky, 1978). This approach comprises three interconnected elements: structures, agency, and cultural practices. Importantly, the SEA examines the impact of mobile learning not only in formal educational settings but also in informal contexts. Given the relevance of this framework to blended learning, the SEA was adopted as the theoretical framework for this study. Within the SEA, structures encompass the entire range of contextual

factors, such as the curriculum, the degree of support provided by schools, teachers, and parents, and the technological infrastructure available at both the school and the student's homes. Agency refers to the abilities of students to effectively learn in a blended learning environment, as well as the capabilities of teachers and parents to facilitate and support student learning. Cultural practices involve collaborative interactions among students, including both peer-to-peer collaboration and collaboration between students and teachers. It also encompasses student communication with classmates, teachers, and parents, as well as the cultural norms and practices established by the students and teachers in the learning process (Pachler et al., 2010).

Blended learning, which combines traditional classroom education and online learning, offers the opportunity for customized and varied instruction to secondary mathematics students. From the existing literature, (Borba et al., 2016) explored the different models of blended learning. It examined the advantages and challenges of using each to teach secondary school mathematics. Christensen and Eyring (2011) categorized most blended programs into four models: Rotation, Flex, A La Carte, and Enriched Virtual. In the rotation model, students in each class rotate between different learning modalities, including online learning, either on a fixed schedule or at the teacher's discretion. The flex model integrates online learning as a significant component, guiding students towards offline activities for each subject. In the a la carte model, students complete entire courses online for certain subjects while other subjects are taught via traditional in-class lessons. The enriched virtual model combines in-class sessions with teachers and the online completion of the remaining subject matter for the same course. In the rotation model, teachers determine how much time is allocated to face-to-face learning and online learning. With respect to the school at the center of this study, blended learning as it was utilized during the COVID-19 suspension of in-class lessons was the flex model, while the enriched virtual model would best describe how blended learning has been implemented in the post-pandemic period.

While blended learning has been extensively studied, most of the studies are based on research conducted in post-secondary settings, including online universities and adult technical education programs. Conversely, studies specifically focused on blended or personalized learning in mathematics at the K-12 levels are relatively limited compared to the overall body of research (Brodersen & Melluzzo, 2017). Fitri and Zahari (2019) argued that blended learning in mathematics offers personalized instruction, flexibility, and accessibility. Digital tools and interactive activities enhance student engagement while creating opportunities for collaboration and communication among the students. However, challenges such as technological limitations, reduced face-to-face interaction, increased student responsibility, and potential inequities in resource access should be considered. Additionally, a study conducted by the Christensen Institute in 2015 examined 12 case studies that showcased how traditional school districts could enhance student learning outcomes, including test scores and graduation rates, through the implementation of blended learning approaches (Mackey, 2015). These findings are consistent with Fazal and Bryant (2019) study.

On the other hand, online learning has its drawbacks. Cole et al. (2014) highlight the negative impacts that online learning environments have on student discipline and retention rates. It is crucial to carefully design the structure, delivery methods, and monitoring systems in order to address technical issues, encourage active participation, and mitigate feelings of isolation. Dissatisfaction among students may arise from high levels of frustration with ICT-related challenges, limited opportunities for interaction, feelings of isolation, and unclear course expectations (Callaway, 2012). Additionally, students lacking ICT skills and perceived self-efficacy may also experience dissatisfaction with online learning (Ilgaz & Gülbahar, 2015).

In short, using blended learning in secondary school mathematics offers a promising approach to combining the benefits of traditional and online learning. Different models of blended learning provide opportunities for flexibility and customization. While challenges exist, such as technological limitations and reduced face-to-face interaction, careful implementation, which considers the various challenges that blended learning can present, would help maximize the advantages and mitigate the drawbacks of using this approach to teach secondary school mathematics. Therefore, further research in mathematics education is needed for K-12 levels.

METHODS

This study examines a secondary mathematics teacher in Hong Kong in terms of his efforts to implement blended learning during and after the pandemic. To do so, this study employs the case study method, which is a suitable methodology for conducting a thorough analysis of a specific phenomenon (Creswell & Creswell, 2017). Drawing upon the example of mathematics lessons, the three-year-long case study (2020-2023) focuses on how the teacher's instructional practices and experiences with blended learning have evolved in response to the changing educational landscape, as well as the demands and limitations presented by the school environment. This study was conducted in a Hong Kong secondary school that primarily serves students of average abilities. The school is located in a commercial/residential neighborhood known as a low to mid-level income area. With an enrolment of approximately 800 students, the school has been operating a BYOD scheme since 2016. With the aid of government funding, every student in the school was equipped with an iPad, enabling them to participate in blended learning. The three-year timeline consists of two distinct phases. During the 2019-2022 academic years, all secondary schools in Hong Kong faced the sudden suspension of in-class lessons due to the COVID-19 pandemic. While conditions eased during the 2021-2022 academic year, thereby allowing in-class lessons on a limited basis, it was not until the 2022-2023 academic year that all schools fully resumed normal operations. This critical period provided an opportunity to explore the benefits and challenges of blended learning during and after the pandemic.

The teacher at the center of the study was a mathematics teacher with about three years of teaching experience at the beginning of the study. He was invited to participate in this study because he has continuously sought to enhance his teaching practices by integrating technology. His interest in the use of technology to teach mathematics pre-dated the pandemic. During the pandemic, he used a variety of IT platforms and tools, such as OneNote, Google Classroom, GeoGebra, and YouTube media. For triangulation purposes, five of the case teacher's students were interviewed during and after the pandemic. Students were selected randomly to avoid any bias or preconceived notions. Data were mainly collected through teacher and student interviews. In addition, lesson materials and student assignments stored online were collected as digital artefacts of the online lessons. The researcher was granted the right to access their school accounts with the consent of the case teachers and students. Table 1 provides a timeline of the significant events over the course of the study.

Table 1. Timeline of the major events in the school and data collection

Time	Events in the school
2019 -2020	• Beginning of suspension of in-class lessons. All students took their lessons online at home.
End of July in 2020	• Interviews of the case teacher and five students • Collection of Data, such as, teacher notes, teaching materials (videos, GeoGebra) and student assignments via Google Classroom and OneNote accounts.
2020-2021	• Limited number in-class lessons at school with the majority of the work done online at home. For example, the students could have 1 face-to-face lesson at school per week.
2022-2023	• Full resumption of in-class lessons.
End of July in 2023	• Interview of the case teacher and another five students. Further collection of lesson materials and student assignments via Google Classroom and OneNote accounts

As the implementation of blended learning was greatly influence by the teaching practices of the teacher as well as other factors in the school environment and the home situations of the students, the SEA was employed as the theoretical framework to examine the research questions and to facilitate the analysis of the data in terms of the three key elements: structures, agency, and cultural practices (Pachler et al., 2010). See Figure 1.

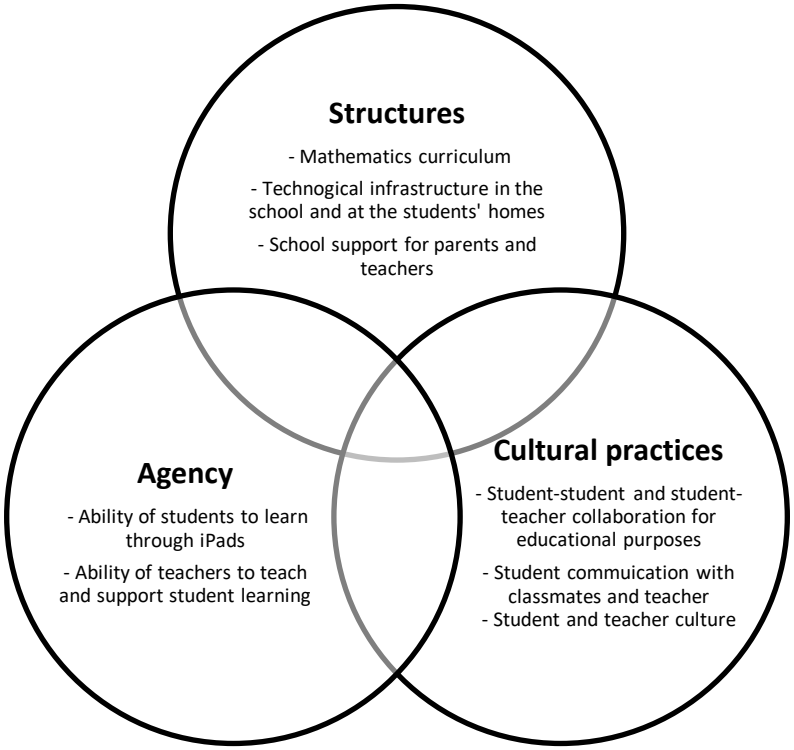


Figure 1. The elements of the current study are arranged in accordance with the SEA framework, modified from Pachler et al. (2010)

Through the SEA lens, this study addressed one overarching research question: What insights and challenges can be gained from implementing blended learning in a secondary school over the 2020-2023 period? This question was further refined into three specific research questions:

RQ1: What are the advantages and disadvantages in terms of structure when it comes to blended learning?

RQ2: What roles and responsibilities do stakeholders have in blended learning?

RQ3: How do cultural practices influence the engagement of each stakeholder in blended learning?

To conduct this study, a teacher and student interview protocol was developed based on SEA to conduct semi-structured interviews (Kiger & Herro, 2015; Pachler et al., 2010; Parsons & Adhikar, 2016). Further, a report by Hong Kong Federation of Education Workers (2016) was used to help design questions specific to the Hong Kong context. The teacher interview questions focused on three primary areas of inquiry: (i) modification and adjustments that were made to the curriculum, (ii) the use of the iPads by both teachers and students and (iii) communications using the iPads. The questions designed for the student interviews were similar to those designed for the teacher interviews. In addition, the students were asked about the amount of home support they received for their online lessons, their use of iPads in school after the pandemic, and the difficulties they experienced using their iPads for learning.

Once the questions were designed, a codebook was created to analyze the interview transcripts (See Figure 2). The coding established a hierarchical order of factors: domain, themes, and subthemes. The first set of subthemes was based on existing literature, whereas new subthemes were added when new ideas emerged from the interview transcripts. Illustrative examples from the transcripts accompanied all codes. The analysis of digital artifacts, such as videos, learning materials, or other documents, served as supplementary information supporting the interview data.

Domain (Pachler, Cook, Bachmair, et al., 2010)	Themes (Parsons & Adhikar, 2016)	Sub-Themes (Parsons & Adhikar, 2016)	Definitions	Examples
Structure	Technological problems	Accessory problems *	All issues/problems related to the iPad accessories, such as earphones, chargers and the Apple Pencils	"When I forget to charge my iPad; I have to bring an external charger because the school rule is forbidden to charge the iPad in school."
		Device problems	All issues/problems related to the functioning of the iPads themselves	"A few students did not charge up their iPads" "Extended one hour of locking time in order to give enough time for me to finish my homework."
		Internet problems	All issues/problems related to the provision of internet service, either at the school or in the homes of the students	"I cannot finish my homework without wi-fi."
		Software problems	All issues/problems related to the software or applications used by the students and teachers	"In *Google Classroom*, when I pull down the screen, all of the homework was lost. I have to do it again."
	Practices related to curriculum	Assessments (Gherardi, 2017a)	Any assessment methods that were adopted and/or issues that arose	"The homework can be synced via the online platform"

Figure 2. An excerpt from the codebook

The study's trustworthiness was achieved via rigorous procedures, including multiple data collection methods, the involvement of various informants, the transparency of the research steps, and the consideration of potential biases. Two researchers coded the transcripts independently, and disagreements in the coding were discussed to arrive at a consensus. The inter-reliability rate was over 80%.

RESULTS AND DISCUSSION

RQ1: What are the Advantages and Disadvantages in Terms of Structure When It Comes to Blended Learning?

Pachler et al. (2010) stated that "structure" encompasses technological and socio-cultural aspects. In 2020 and 2023, various technological issues arose, including problems related to devices, software, and internet connectivity. Additionally, as students were learning slower in 2020 due to the pivot to online lessons, teachers could only cover part of the mathematics curriculum. To address these challenges, parents supported their children by supervising their online lessons and offering technological assistance. Therefore, the structures considered in this study encompassed technological problems at home, curriculum-related issues with respect to online lessons, and the support provided by families. It is worth noting that these issues have subsided in the post-pandemic period.

Technological Problems

The BYOD scheme caused technological issues in both in-class and online lessons, including device problems, connectivity, and software issues. Students should have mentioned accessory-related problems during online lessons. Some students reported that the battery life of the iPads needed to be improved for online lessons, while others couldn't charge their iPads at home. Software-related issues included unexpected app closures and difficulties logging into Zoom. Internet connectivity problems varied between in-class and online lessons. Some students faced difficulties with home internet connections, which affected their ability to participate. Some students found the iPads suitable for online learning, while others used two devices simultaneously for efficiency. In addition, for mathematics lessons, the split-screen function allowed the students to watch teachers explain mathematics problems and write their own notes simultaneously.

Learning Materials Beyond the Boundaries of the Curriculum

Compared to regular in-class lessons, the curriculum was condensed during the pandemic, and only a limited number of challenging topics were taught via online lessons. This reduction in the curriculum was taken to accommodate the constraints and limitations of the online learning environment.

During the pandemic, some of the teachers at the school created their own teaching videos, primarily focusing on the curriculum material. This was done because some students could not attend online lessons due to internet connectivity issues. Before the pandemic, the teacher in this study intended to play the videos during class. However, with the onset of the pandemic, the use of videos expanded beyond the classroom as the videos were made available to the students as supplementary learning materials more systematically. With the videos, students could watch the lessons repeatedly and use them for revision purposes. While creating teaching videos can be time-consuming for teachers, only about 20% of the students still need to watch the videos. From 2020 to 2023, the teaching videos transitioned from being a school-based resource to an online resource. As a result, after the pandemic, most of the videos can be found on the internet, particularly on platforms like YouTube, and they exist mainly for teaching purposes. These videos offer extended discussions of the topics that go beyond what is typically taught in class. When the school returned to in-class teaching, these videos served as complementary resources, providing additional explanations, examples, and perspectives. For instance, one of the videos discusses an alternative method to prove 0! (factorial), which is not commonly included in the standard curriculum. The availability of teaching videos serves several purposes, such as pre-learning tasks, providing extended learning materials, and offering additional explanations of more difficult

mathematics topics for students to study at home. Students have recognized the value of these videos as they enrich their knowledge and enhance their engagement with the subject matter.

Integrating materials beyond the curriculum's boundaries, such as teaching videos, has brought changes and benefits to post-pandemic education. For instance, Bhagat et al. (2016) conducted a study demonstrating how educational videos effectively enhance learning and engagement in high school mathematics education. In a review of the literature, Yang et al. (2021) determined that there is a general consensus among the studies, which indicates that the implementation of the technology-enhanced learning models has positively impacted learning outcomes and student motivation. However, it is worth noting that most of the studies included in the review utilized videos as pre-class materials. By contrast, the school in this particular study uses their videos as an online source of supplementary material. Transitioning the school's videos into an online one was significant because it was designed to help teachers minimize their workload. This aligns with the findings of Insorio and Macandog's (2022) study, which emphasized the importance of considering the teacher's workload and student self-discipline when incorporating digital resources into instruction in a natural school setting. Here, it is worth noting that several funded projects in Hong Kong have produced online learning resources, which are subsequently uploaded to a platform dedicated to sharing teaching videos among local secondary schools. Figure 3 (below) provides an example of a video explaining the idea of inequality per the local curriculum.

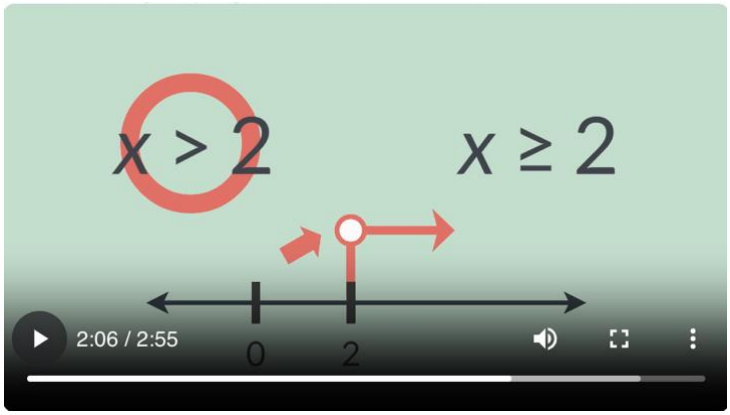


Figure 3. A video from the "Blended Learning" Project, funded by The Hong Kong Jockey Club Charities Trust

The findings of this study align with previous studies on the advantages and disadvantages of structure in blended learning environments. The identified technological challenges, such as device issues, software problems, and internet connectivity issues, are consistent with previous studies (Bidarra & Rusman, 2017; Borba et al., 2016; Rasheed et al., 2020). The challenges reported in this study illustrate the structural elements that the teacher needed to overcome during the pandemic. Thus, strategies to improve device functionality, software reliability, and internet connectivity should be explored to enhance the overall structure of blended learning.

Parental Support and the Digital Divide

During the pandemic, parents played a significant role in supporting students at home. This support came from assisting their children with technological issues and/or supervising their participation in online lessons. Parental involvement was crucial to ensure their children had a positive learning experience during their online lessons. At the same time, some parents faced their own challenges and/or constraints that prevented them from offering the necessary assistance to their children. This limited their ability to support their children during online lessons, which has led to a digital divide. This means that some

students need help obtaining help when encountering issues at home, negatively impacting their online learning experience. It is worth noting that some of these issues have subsided in the post-pandemic period. Furthermore, not all parents possess the necessary knowledge in mathematics to support students effectively during online mathematics lessons. One of the major findings of this study is the significant impact of the disparity in parental support regarding digital capability.

The divide in digital capability and outcomes, as proposed by Adhikari et al. (2017), consists of three distinct levels that determine the extent of digital access, capability, and outcomes. These levels help us understand how different factors contribute to the divide and subsequently affect parental support. In the case of the school at the center of this study, it is essential to note that all of the students are equipped with iPads and have access to Wi-Fi at home, thanks to government funding. This ensures that all of the students have equal opportunities to engage with digital technologies. However, it is essential to examine the role of parental support in bridging the digital divide and maximizing the potential benefits for students. Based on the HKU e360 report (2023) data, parental support plays a crucial role in minimizing online risks and maximizing the potential of the digital world. The report emphasizes the importance of factors such as establishing family media boundaries, parents' knowledge of technology, and consistent parenting practices. These aspects of parental support contribute to creating a safe, nurturing environment for children in the digital realm. We understand how these factors are interconnected by clarifying the relationship between parental support and the digital capability and outcome divide.

RQ2: What Roles and Responsibilities Do Stakeholders Have in Blended Learning?

Agency refers to users' capacity to act in their learning environment. In the context of blended learning, the use of mobile devices enhanced student motivation and facilitated their ability to learn. However, it is essential to acknowledge that using iPads also negatively affects the students, including distractions and potential health issues. From the teachers' perspective, mobile devices opened exciting new dimensions to their teaching practices. They provided a convenient means to distribute and collect learning materials, and school-based videos proved helpful for teachers to cater to the diverse learning needs of their students, particularly during mathematics lessons. However, the use of iPads also posed discipline-related challenges in the classroom. As a result of the analysis, four distinct themes emerged: positive student agency, negative student agency, positive teacher agency, and negative teacher agency. These themes shed light on the various ways in which mobile devices can both empower and hinder students and teachers in the context of blended learning. It is worth noting that these themes were observed in both the 2020 and 2023 evaluations of blended learning.

Student Agency (Positive)

Using mobile devices for online lessons enhanced the students' motivation, similar to the impact observed in regular in-class lessons. Students could boost their motivation through various learning tasks facilitated by mobile devices. In addition to motivation, students and teachers acknowledged the ease with which students could access and organize learning materials and homework in online and in-class lessons. In particular, using e-platforms, such as OneNote and Google Classroom, facilitated efficient management and retrieval of resources for both students and teachers.

With respect to mathematics, students were able to use their mobile devices (iPads) further to look up and translate English words found in mathematics textbooks. Three students specifically mentioned using an electronic dictionary to translate unfamiliar terms such as "transformation" and "translating." In

addition to word meanings, two students also utilized the iPad to search for additional learning materials related to challenging parts of the curriculum. When students face challenges while attempting mathematics questions, they can search for similar topics, such as the method for finding the area of polygons, on YouTube. One notable feature was the split-screen function, which enabled students to attend online lessons while simultaneously taking notes on their devices.

Student Agency (Negative)

In both 2020 and 2023, the data revealed that students were distracted by their iPads, engaging in activities like gaming, watching YouTube, and texting friends. Other distractions at home, such as pets, food, or family members, also affected their focus during online lessons. Students agreed that distractions were more prevalent during the suspension of in-class lessons, especially when they faced difficult questions. Furthermore, students were also concerned about health problems, particularly eye problems and fatigue stemming from using their iPads for long hours.

Teacher Agency (Positive)

The BYOD scheme ensures that every student at the participating school has a mobile device, making it easier for teachers to conduct online lessons. At the same time, as the students are familiar with their mobile devices, they can quickly attend online lessons via platforms like Zoom. This facilitated seamless teaching and interaction between teachers and students. In both 2020 and 2023, the use of the iPad enabled teachers to deliver and collect teaching materials effectively. Figure 4 (below) illustrates how OneNote provides a clear interface for teachers to review and correct work submitted by their students. During the suspension of in-class lessons, students were required to stay at home, thereby making it impossible for teachers to provide hard copies of teaching materials. Instead, they could send all the necessary resources to their students through their mobile devices. Students had the option to answer questions using the Apple Pencil, while a few others chose to print the materials and write their answers on paper. These written responses could then be sent back to teachers using the camera function on their mobile devices. This process allowed for efficient distribution and collection of teaching materials in remote learning settings.

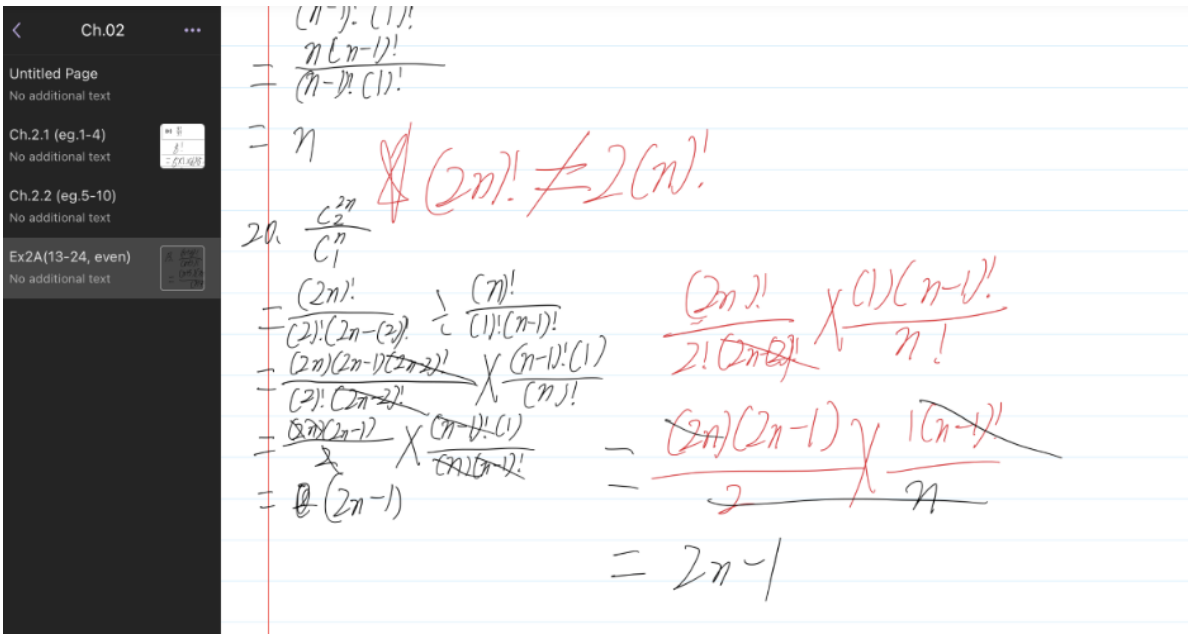


Figure 4. Teacher's Notes using OneNote

Additionally, the pandemic forced teachers to become more proficient with iPads and explore new ideas for integrating them into their teaching. In Figures 5 and 6, the teacher can be seen using the iPad to offer feedback on a student submission (Figure 5) and to provide illustrative examples (Figure 6) using OneNote, both of which could be efficiently shared with the students during the course of a lesson.

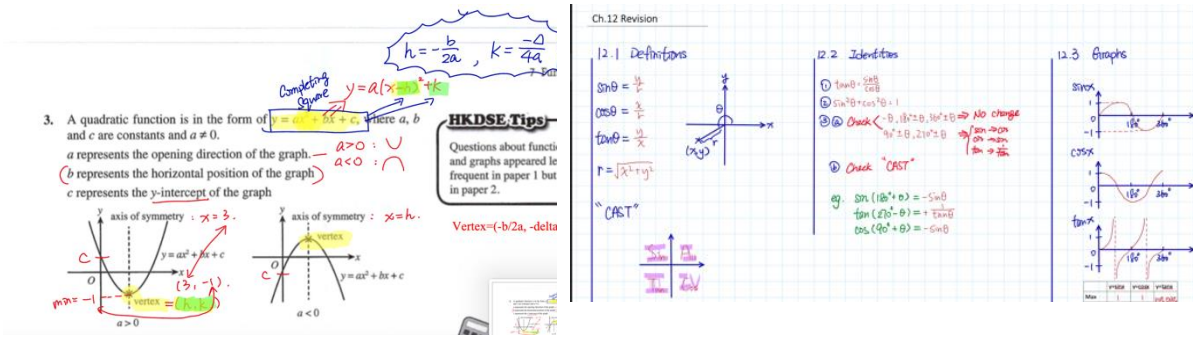


Figure 5. Teacher's Notes using OneNote

Moreover, teachers can further enhance their lessons by embedding GeoGebra into a OneNote page, as illustrated in Figure 7, which allows students to interactively explore various mathematical concepts. Lessons on mathematics topics such as the transformation of graphs and locus were greatly enhanced, and students could visualize the movement of a graph as the variables were changed.

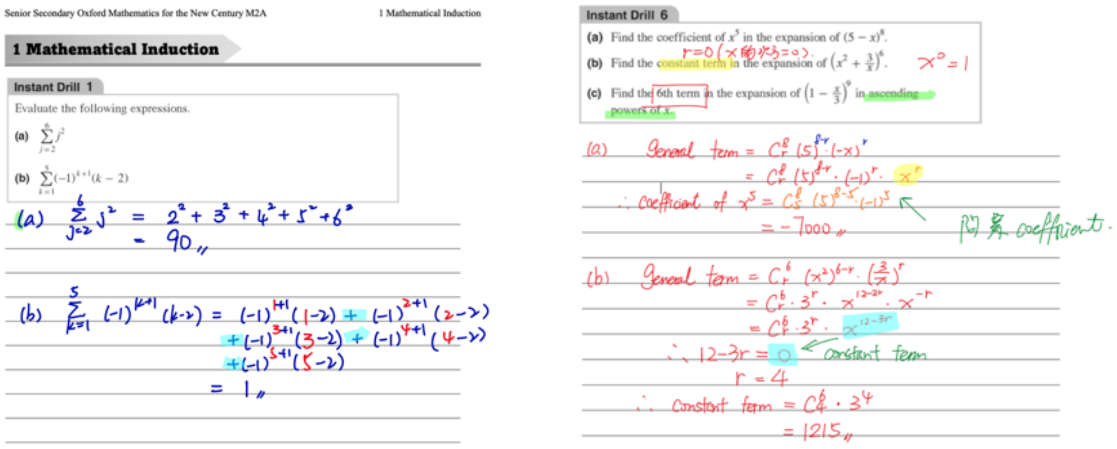


Figure 6. Teacher's Model Solution

These versatile learning tasks serve a number of purposes, including pre-learning activities, in-class exercises, and supplementary materials. The students have agreed that the benefits of using iPads and interactive tools not only enrich the learning experience, but also enhance their engagement with the subject matter.

Even before the onset of pandemic, the teacher had shared numerous examples of mathematical proofs and classwork with students via OneNote as part of the school's BYOD program. However, after the pandemic, the teacher extensively utilized OneNote to share a wide range of teaching resources and other information that he believed could help the students.

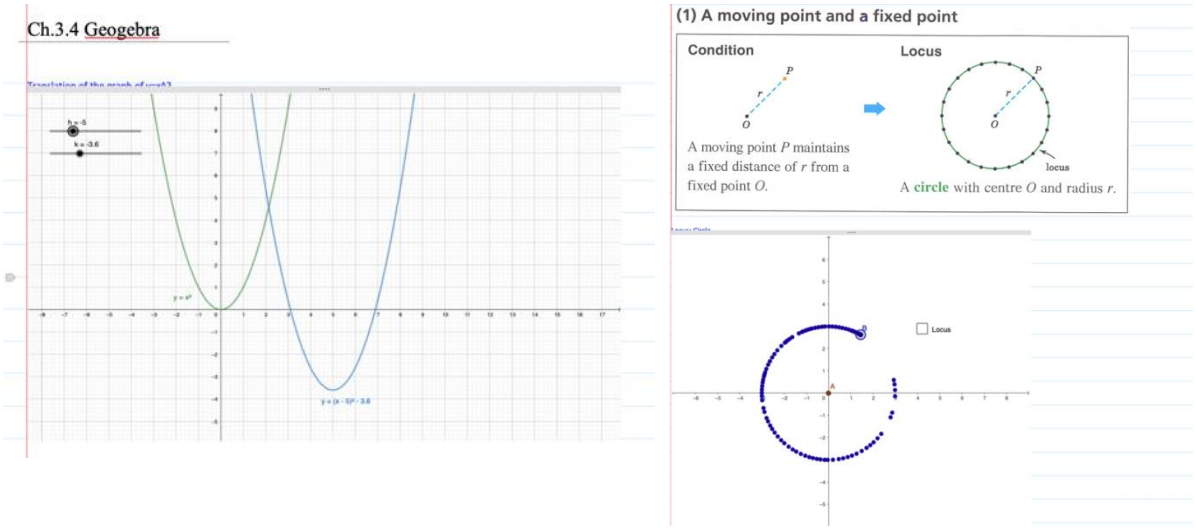
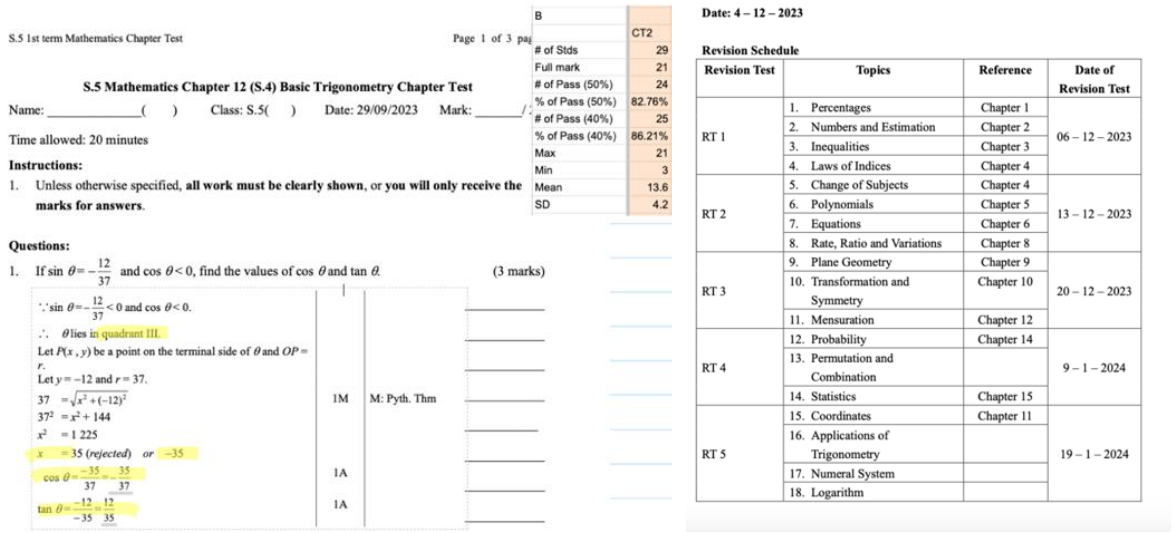


Figure 7. GeoGebra in OneNote

This included study schedules for test preparation, examination answer keys with highlights added by the teacher, and the overall class statistics regarding their mathematics performance (See Figure 8). This shift was significant as the pandemic empowered the teacher to explore different usages for the iPad and effectively organize a whole range of information for the benefit of the students.



S.5 1st term Mathematics Chapter Test Page 1 of 3 pag

S.5 Mathematics Chapter 12 (S.4) Basic Trigonometry Chapter Test

Name: _____( ) Class: S.5( ) Date: 29/09/2023 Mark: _____/

Time allowed: 20 minutes

Instructions:

1. Unless otherwise specified, **all work must be clearly shown**, or **you will only receive the marks for answers**.

B	CT2
# of Stds	29
Full mark	21
# of Pass (50%)	24
% of Pass (50%)	82.76%
# of Pass (40%)	25
% of Pass (40%)	86.21%
Max	21
Min	3
Mean	13.6
SD	4.2

Questions:

1. If $\sin\theta = -\frac{12}{37}$ and $\cos\theta < 0$, find the values of $\cos\theta$ and $\tan\theta$. (3 marks)

$\because \sin\theta = -\frac{12}{37} < 0$ and $\cos\theta < 0$.

$\therefore$ θ lies in quadrant III.

Let $P(x, y)$ be a point on the terminal side of θ and $OP = r$.

Let $y = -12$ and $r = 37$.

$37 = \sqrt{x^2 + (-12)^2}$ 1M M: Pyth. Thm

$37^2 = x^2 + 144$

$x^2 = 1\,225$

$x = 35$ (*rejected*) or -35

$\cos\theta = \frac{-35}{37} = -\frac{35}{37}$ 1A

$\tan\theta = \frac{-12}{-35} = \frac{12}{35}$ 1A

Date: 4 – 12 – 2023

Revision Schedule

Revision Test	Topics	Reference	Date of Revision Test
RT 1	1. Percentages	Chapter 1	06 – 12 – 2023
	2. Numbers and Estimation	Chapter 2	
	3. Inequalities	Chapter 3	
	4. Laws of Indices	Chapter 4	
RT 2	5. Change of Subjects	Chapter 4	13 – 12 – 2023
	6. Polynomials	Chapter 5	
	7. Equations	Chapter 6	
	8. Rate, Ratio and Variations	Chapter 8	
RT 3	9. Plane Geometry	Chapter 9	20 – 12 – 2023
	10. Transformation and Symmetry	Chapter 10	
	11. Mensuration	Chapter 12	
RT 4	12. Probability	Chapter 14	9 – 1 – 2024
	13. Permutation and Combination		
	14. Statistics	Chapter 15	
RT 5	15. Coordinates	Chapter 11	19 – 1 – 2024
	16. Applications of Trigonometry		
	17. Numeral System		
	18. Logarithm		

Figure 8. Other information provided through OneNote

Teacher Agency (Negative)

One primary challenge of teaching online lessons through mobile devices in 2020 was the limited opportunities for hands-on activities. For example, the teacher could not use physical 3D models to let students explore the total surface area of a solid (See Figure 9). Regarding discipline, teachers found that they could not monitor students as closely as they could during in-class lessons. Teachers reported instances where students used the iPad to watch YouTube videos during the lessons. Moreover, students' lack of camera usage made it difficult for teachers to determine whether or not students were actively participating in the lessons. This lack of ability to supervise the students made it very challenging for the teacher to monitor and ensure discipline among students during online lessons.

Figure 9. Teaching Aids: Physical 3D Models

The adoption of iPads and interactive tools by teachers in the post-pandemic era also aligns with the literature on blended learning in mathematics education. Research has demonstrated the positive impact of using iPads and interactive tools on student engagement and motivation. For example, both Bright et al. (2024) and Yang et al. (2021) provide evidence regarding the positive impact of integrating technology into mathematics instruction. Indeed, the integration of online videos and tools like GeoGebra have facilitated the adoption of an enriched virtual model in post-pandemic education. This model combines in-class learning sessions with teachers and online completion of the remaining subject matter, allowing for a flexible and personalized learning experience.

Further, the findings of this study are also consistent with existing studies on blended learning and the use of mobile devices. For instance, studies have consistently shown that mobile devices can enhance student motivation and engagement in learning activities (Ali, 2024; Lee et al., 2019; Parsons & Adhikar, 2016; Rajabalee et al., 2020). Similarly, the challenges related to distractions and health issues associated with device usage have been reported in several studies (Janssen & Phillipson, 2015; Ott et al., 2018). This study contributes to the growing body of literature on blended learning by highlighting these connections. It provides further evidence regarding the benefits and challenges associated with using mobile devices in education.

RQ3: How do Cultural Practices Influence Stakeholders' Engagement in Blended Learning?

Mobile devices, including iPads, have increasingly become a tool for social communication. Learning is now seen as a process of meaning-making that occurs both inside and outside of schools, incorporating situated learning principles (Pachler et al., 2010). In the context of this study, iPads played a significant role in enhancing the ability of students to communicate with their classmates and teachers in both 2020 and 2023. Additionally, the students also utilized their iPads for entertainment purposes. Teachers also found that the iPads provided a valuable means to deliver individualized feedback to each student. As a result, cultural practices in this study encompassed feedback, student culture, and teacher culture, all of which were influenced by the use of iPads as mobile devices for communication and learning.

Student Culture

The use of mobile devices for communication, particularly during online lessons in 2020 and 2023, positively impacted the students. When teachers did not provide their mobile phone numbers, students

could still communicate through email when they could not attend online lessons. Additionally, students utilized Google Chat on their iPads to ask their teachers questions regarding homework problems, including submitting assignments and resolving issues. In addition to communicating with teachers, the students also used iPads to interact with their classmates. Even with mathematics homework, online technology can break the physical boundaries between students.

Since they were not allowed to leave their homes during the COVID-19 pandemic, the students relied on the iPads for communication and collaboration. They stored all of their study materials on their iPads and utilized platforms like Zoom to work on assignments together and engage in leisure activities. This demonstrates how iPads played a crucial role in addressing many of the daily life challenges faced by students during the pandemic. Notably, the students expressed interest in using mobile devices for leisure activities such as playing games or watching YouTube, a pattern consistent with in-class lessons.

Providing Feedback to Students

The teacher started using the iPad to provide feedback to the students before the pandemic as part of the BYOD program. After the pandemic, the teacher has adopted a significantly more systematic and widespread approach to collecting assignments from his students and providing feedback. OneNote continues to serve as a comprehensive platform for all of the teachers and students to manage their work, including homework, quizzes, tests, and examination papers.

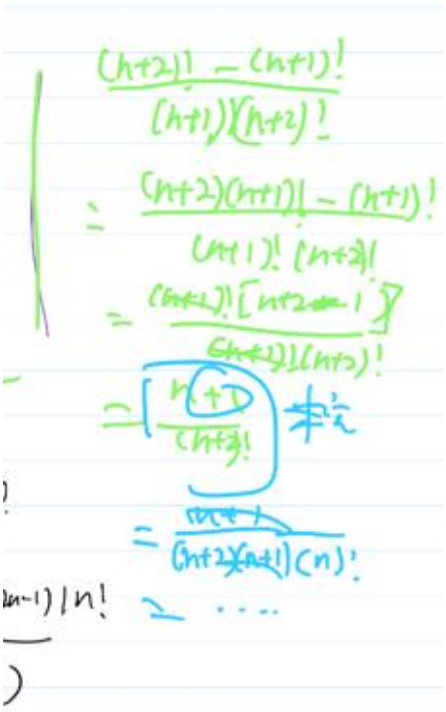


Figure 10. Reducing algebraic expressions to the simplest form

The teacher regularly scans quizzes, tests, and examination papers, uploads them to OneNote, marks them, and adds comments digitally. This centralized system significantly streamlines the organization and distribution of assignments, offering convenience for both teachers and students when it comes to accessing and revising their work.

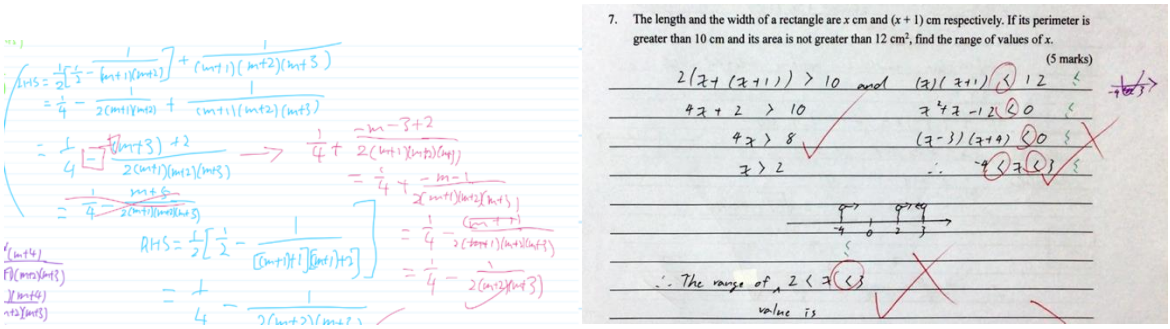


Figure 11. Using the wrong concepts for quadratic inequality

The digital platform allows teachers to track their student's progress and enables them to deliver feedback more organized and efficiently. These benefits have continued to be relevant in the post-pandemic period, providing a streamlined and effective way for teachers and students to interact with each other. One of the benefits for the students is that it allows them to revise their work according to feedback from their teachers efficiently.

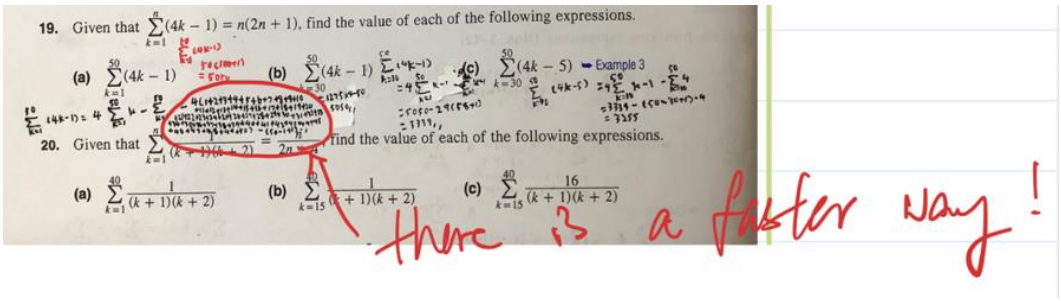


Figure 12. Suggesting Alternative Methods

This timely and constructive feedback could include small but essential details, such as proper use of symbols, reducing mathematical expressions to the simplest form (See Figure 10), using the wrong concepts for polynomials and quadratic inequality (See Figure 11), suggesting alternative methods (See Figure 12), missing explanations in geometric proofs (See Figure 13), missing units, appropriate graphical representations, etc. This development has been significant as the teacher argued that revising and reviewing student submissions using OneNote is much easier.

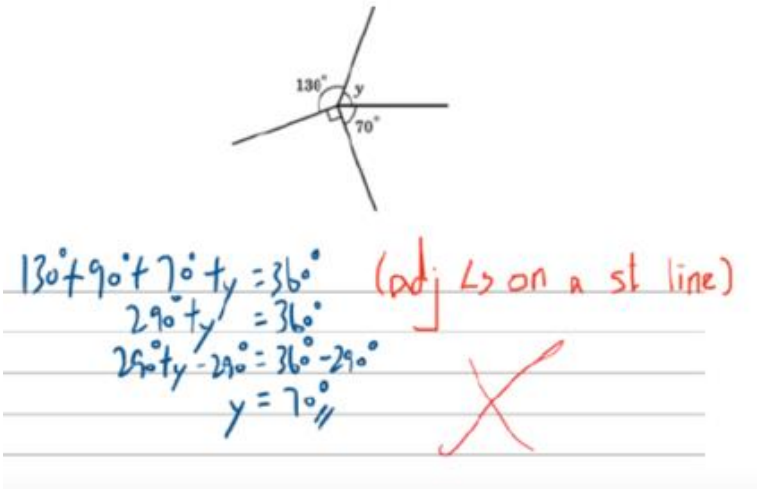


Figure 13. Missing Explanation in Proofs

Teacher Culture

In 2020 and 2023, teachers collaborated to reduce their workload by sharing school-based mathematics teaching videos. The mathematics panel distributed the videos among different forms (or grades). This arrangement meant that teachers did not have to design and record every video they wanted individually. By sharing resources and responsibilities, teachers could effectively manage their workload and ensure that students had access to quality teaching materials for mathematics. At the same time, the students could use as many of the videos as they wanted to solve their individual problems.

The findings of this study shed light on the influence of cultural practices on the engagement of each stakeholder in blended learning. The use of mobile devices shaped the cultural practices observed. In particular, as all of the students owned their mobile devices (iPads), they played a significant role in fostering engagement among students and teachers. The use of iPads for communication and collaboration has positively impacted student culture. Students use iPads to communicate with their teachers and classmates, seeking clarification on homework problems and sharing learning materials. This enhanced communication between teachers and students, as well as between the teachers themselves, facilitated a sense of connection and support, leading to increased engagement in learning activities. The cultural practice of collaboration among teachers, exemplified by the sharing of school-based mathematics teaching videos, has not only reduced the workload of individual teachers but also ensured that students have access to high-quality teaching materials. These collaborative practices contributed to a supportive and engaging learning environment.

These findings are consistent with previous studies on the influence of cultural practices on engagement in blended learning. Studies have consistently emphasized the importance of communication and collaboration in enhancing student engagement and learning outcomes (Czerkawski & Lyman, 2016; Haythornthwaite, 2006; Nortvig et al., 2018). Furthermore, the use of mobile devices, such as the iPads used in this study, has been recognized as a facilitator of communication and collaboration among both students and teachers (Biasutti, 2011; Minga & Ghosh, 2024; Nortvig et al., 2018). Moreover, their use in blended learning has enabled teachers to provide individual feedback for each student (Bonk et al., 2002; Margolis et al., 2017). This study also highlights an important point regarding the centralization of the feedback channels. In a traditional school setting, teachers provide feedback through various avenues, such as homework, classwork, quizzes, tests, and examinations. Therefore, a centralized platform is essential for teachers to manage this feedback in a natural school setting effectively. By reinforcing these existing findings, this study adds to the growing body of literature on the role of cultural practices in blended learning. The data is also consistent with the existing literature regarding sharing teaching materials, which is essential for implementing blended learning (Crawford & Jenkins, 2017; Tynan et al., 2015).

CONCLUSION

From 2020 to 2023, the pandemic led to the empowerment of teachers and the widespread adoption of the iPad as a tool for teaching. During this time, the teachers made efforts to systematically provide a wide range of learning resources and information to students through the use of the iPads. The teacher in this study served as a valuable exemplar, demonstrating how technology can transform traditional teaching practices into a more systematic and accessible approach, particularly in the context of demonstrating and providing mathematics examples. While alternative resources such as GeoGebra and YouTube videos were explored, their utilization could have been more widespread. The challenge is that

those online materials need to fit the Hong Kong mathematics curriculum well. However, incorporating a wide range of resources shows promise for the future development of the Hong Kong mathematics curriculum, which could potentially enhance the effectiveness of blended learning approaches.

The identified themes of positive and negative student and teacher agency in blended learning with mobile devices have important implications for educational practice. The positive aspects, such as enhanced motivation and easy access to learning materials, can improve student engagement and learning outcomes. Educators can leverage these findings by incorporating mobile devices effectively into their teaching strategies, designing engaging activities, and utilizing online platforms for resource distribution. On the other hand, the negative aspects, such as distractions and health concerns, highlight the need to optimize the learning environment. Teachers can explore strategies to minimize distractions during online lessons, such as implementing time management techniques or using monitoring tools. Additionally, measures should be taken to address the health issues related to prolonged device usage, such as encouraging regular breaks and promoting proper ergonomics.

The study highlights the persistent technological challenges students face, ranging from device-related issues to software disruptions and issues related to internet connectivity. These challenges underscore the importance of robust technological infrastructures to support practical blended learning experiences. The observed curriculum adaptations, particularly the condensation of content during online lessons, emphasize the need for flexibility and tailored approaches to meet the unique demands of blended learning. Additionally, the pandemic significantly impacted teaching, particularly in instructional videos, interactive tools, and centralized feedback systems, resulting in enhanced student learning and motivation.

Furthermore, the crucial role of parental support in bridging the digital divide has been elucidated. This study is consistent with Adhikari's framework, which emphasizes the significance of parental involvement in minimizing online risks and maximizing the potential benefits for students. Incorporating findings from the HKU e306 report enhances the study's credibility, emphasizing the broader implications of parental support in addressing online risks.

Moving forward, this study underscores the implications of positive and negative agency in blended learning for both students and teachers. Leveraging the positive aspects, such as enhanced motivation and easy access to learning materials, offers opportunities for educators to optimize teaching strategies. Simultaneously, mitigating distractions and addressing health concerns associated with device usage call for proactive measures to create an optimal learning environment. The exploration of cultural practices in the context of blended learning demonstrates the positive impact of iPads on student communication and collaboration. The findings reinforce the importance of cultural practices in fostering engagement among students and teachers, emphasizing the need for continued support and collaboration.

Theoretically, this study reinforces the validity of using the SEA as a tool to interpret and evaluate school-based implementations of blended learning. From a practical point of view, this study advances our understanding of the structural constraints of blended learning, as well as the roles of the stakeholders and cultural influences. The identified challenges and opportunities provide a scientific justification for blended learning approaches' ongoing development and refinement. The study's findings offer valuable insights for practitioners, policymakers, and parents, emphasizing the need for tailoring strategies to enhance the effectiveness of blended learning in diverse educational settings to optimize the blended learning landscape.

Declarations

Author Contribution : TMY: Conceptualization, Writing - Original Draft, Editing and Visualization. MAC: Validation and Supervision.

Conflict of Interest : The authors declare no conflict of interest.

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