

Students' experience of online learning during the COVID-19 pandemic: A province-wide survey study

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Abstract

Online learning is currently adopted by educational institutions worldwide to provide students with ongoing education during the COVID-19 pandemic. Even though online learning research has been advancing in uncovering student experiences in various settings (i.e., tertiary, adult, and professional education), very little progress has been achieved in understanding the experience of the K-12 student population, especially when narrowed down to different school-year segments (i.e., primary and secondary school students). This study explores how students at different stages of their K-12 education reacted to the mandatory full-time online learning during the COVID-19 pandemic. For this purpose, we conducted a province-wide survey study in which the online learning experience of 1,170,769 Chinese students was collected from the Guangdong Province of China. We performed cross-tabulation and Chi-square analysis to compare students' online learning conditions, experiences, and expectations. Results from this survey study provide evidence that students' online learning experiences are significantly different across school years. Foremost, policy implications were made to advise government authorities and schools on improving the

delivery of online learning, and potential directions were identified for future research into K-12 online learning.

KEYWORDS

e-learning, learner attitudes/perceptions, primary education, questionnaire, secondary education

Practitioner notes

What is already known about this topic

- Online learning has been widely adopted during the COVID-19 pandemic to ensure the continuation of K-12 education.
- Student success in K-12 online education is substantially lower than in conventional schools.
- Students experienced various difficulties related to the delivery of online learning.

What this paper adds

- Provide empirical evidence for the online learning experience of students in different school years.
- Identify the different needs of students in primary, middle, and high school.
- Identify the challenges of delivering online learning to students of different age.

Implications for practice and/or policy

- Authority and schools need to provide sufficient technical support to students in online learning.
- The delivery of online learning needs to be customised for students in different school years.

INTRODUCTION

The ongoing COVID-19 pandemic poses significant challenges to the global education system. By July 2020, the UN Educational, Scientific and Cultural Organization (2020) reported nationwide school closure in 111 countries, affecting over 1.07 billion students, which is around 61% of the global student population. Traditional brick-and-mortar schools are forced to transform into full-time virtual schools to provide students with ongoing education (Van Lancker & Parolin, 2020). Consequently, students must adapt to the transition from face-to-face learning to fully remote online learning, where synchronous video conferences, social media, and asynchronous discussion forums become their primary venues for knowledge construction and peer communication.

For K-12 students, this sudden transition is problematic as they often lack prior online learning experience (Barbour & Reeves, 2009). Barbour and LaBonte (2017) estimated that even in countries where online learning is growing rapidly, such as USA and Canada, less than 10% of the K-12 student population had prior experience with this format. Maladaptation to online learning could expose inexperienced students to various vulnerabilities, including decrements in academic performance (Molnar et al., 2019), feeling of isolation (Song et al., 2004), and lack of learning motivation (Muilenburg & Berge, 2005). Unfortunately, with confirmed cases continuing to rise each day, and new outbreaks occur on a global scale,

full-time online learning for most students could last longer than anticipated (World Health Organization, 2020). Even after the pandemic, the current mass adoption of online learning could have lasting impacts on the global education system, and potentially accelerate and expand the rapid growth of virtual schools on a global scale (Molnar et al., 2019). Thus, understanding students' learning conditions and their experiences of online learning during the COVID pandemic becomes imperative.

Emerging evidence on students' online learning experience during the COVID-19 pandemic has identified several major concerns, including issues with internet connection (Agung et al., 2020; Basuony et al., 2020), problems with IT equipment (Bączek et al., 2021; Niemi & Kousa, 2020), limited collaborative learning opportunities (Bączek et al., 2021; Yates et al., 2020), reduced learning motivation (Basuony et al., 2020; Niemi & Kousa, 2020; Yates et al., 2020), and increased learning burdens (Niemi & Kousa, 2020). Although these findings provided valuable insights about the issues students experienced during online learning, information about their learning conditions and future expectations were less mentioned. Such information could assist educational authorities and institutions to better comprehend students' difficulties and potentially improve their online learning experience. Additionally, most of these recent studies were limited to higher education, except for Yates et al. (2020) and Niemi and Kousa's (2020) studies on senior high school students. Empirical research targeting the full spectrum of K-12 students remain scarce. Therefore, to address these gaps, the current paper reports the findings of a large-scale study that sought to explore K-12 students' online learning experience during the COVID-19 pandemic in a provincial sample of over one million Chinese students. The findings of this study provide policy recommendations to educational institutions and authorities regarding the delivery of K-12 online education.

LITERATURE REVIEW

Learning conditions and technologies

Having stable access to the internet is critical to students' learning experience during online learning. Berge (2005) expressed the concern of the divide in digital-readiness, and the pedagogical approach between different countries could influence students' online learning experience. Digital-readiness is the availability and adoption of information technologies and infrastructures in a country. Western countries like America (3rd) scored significantly higher in digital-readiness compared to Asian countries like China (54th; Cisco, 2019). Students from low digital-readiness countries could experience additional technology-related problems. Supporting evidence is emerging in recent studies conducted during the COVID-19 pandemic. In Egypt's capital city, Basuony et al. (2020) found that only around 13.9% of the students experienced issues with their internet connection. Whereas more than two-thirds of the students in rural Indonesia reported issues of unstable internet, insufficient internet data, and incompatible learning device (Agung et al., 2020).

Another influential factor for K-12 students to adequately adapt to online learning is the accessibility of appropriate technological devices, especially having access to a desktop or a laptop (Barbour et al., 2018). However, it is unlikely for most of the students to satisfy this requirement. Even in higher education, around 76% of students reported having incompatible devices for online learning and only 15% of students used laptop for online learning, whereas around 85% of them used smartphone (Agung et al., 2020). It is very likely that K-12 students also suffer from this availability issue as they depend on their parents to provide access to relevant learning devices.

Technical issues surrounding technological devices could also influence students' experience in online learning. (Barbour & Reeves, 2009) argues that students need to have a high level of digital literacy to find and use relevant information and communicate with others through technological devices. Students lacking this ability could experience difficulties in online learning. Bączek et al. (2021) found that around 54% of the medical students experienced technical problems with IT equipment and this issue was more prevalent in students with lower years of tertiary education. Likewise, Niemi and Kousa (2020) also find that students in a Finish high school experienced increased amounts of technical problems during the examination period, which involved additional technical applications. These findings are concerning as young children and adolescent in primary and lower secondary school could be more vulnerable to these technical problems as they are less experienced with the technologies in online learning (Barbour & LaBonte, 2017). Therefore, it is essential to investigate the learning conditions and the related difficulties experienced by students in K-12 education as the extend of effects on them remain underexplored.

Learning experience and interactions

Apart from the aforementioned issues, the extent of interaction and collaborative learning opportunities available in online learning could also influence students' experience. The literature on online learning has long emphasised the role of effective interaction for the success of student learning. According to Muirhead and Juwah (2004), interaction is an event that can take the shape of any type of communication between two or subjects and objects. Specifically, the literature acknowledges the three typical forms of interactions (Moore, 1989): (i) student-content, (ii) student-student, and (iii) student-teacher. Anderson (2003) posits, in the well-known interaction equivalency theorem, learning experiences will not deteriorate if only one of the three interaction is of high quality, and the other two can be reduced or even eliminated. Quality interaction can be accomplished by across two dimensions: (i) structure—pedagogical means that guide student interaction with contents or other students and (ii) dialogue—communication that happens between students and teachers and among students. To be able to scale online learning and prevent the growth of teaching costs, the emphasise is typically on structure (i.e., pedagogy) that can promote effective student-content and student-student interaction. The role of technology and media is typically recognised as a way to amplify the effect of pedagogy (Lou et al., 2006). Novel technological innovations—for example learning analytics-based personalised feedback at scale (Pardo et al., 2019)—can also empower teachers to promote their interaction with students.

Online education can lead to a sense of isolation, which can be detrimental to student success (McInerney & Roberts, 2004). Therefore, integration of social interaction into pedagogy for online learning is essential, especially at the times when students do not actually know each other or have communication and collaboration skills underdeveloped (Garrison et al., 2010; Gašević et al., 2015). Unfortunately, existing evidence suggested that online learning delivery during the COVID-19 pandemic often lacks interactivity and collaborative experiences (Bączek et al., 2021; Yates et al., 2020). Bączek et al., (2021) found that around half of the medical students reported reduced interaction with teachers, and only 4% of students think online learning classes are interactive. Likewise, Yates et al. (2020)'s study in high school students also revealed that over half of the students preferred in-class collaboration over online collaboration as they value the immediate support and the proximity to teachers and peers from in-class interaction.

Learning expectations and age differentiation

Although these studies have provided valuable insights and stressed the need for more interactivity in online learning, K-12 students in different school years could exhibit different expectations for the desired activities in online learning. Piaget's Cognitive Developmental Theory illustrated children's difficulties in understanding abstract and hypothetical concepts (Thomas, 2000). Primary school students will encounter many abstract concepts in their STEM education (Uttal & Cohen, 2012). In face-to-face learning, teachers provide constant guidance on students' learning progress and can help them to understand difficult concepts. Unfortunately, the level of guidance significantly drops in online learning, and, in most cases, children have to face learning obstacles by themselves (Barbour, 2013). Additionally, lower primary school students may lack the metacognitive skills to use various online learning functions, maintain engagement in synchronous online learning, develop and execute self-regulated learning plans, and engage in meaningful peer interactions during online learning (Barbour, 2013; Broadbent & Poon, 2015; Huffaker & Calvert, 2003; Wang et al., 2013). Thus, understanding these younger students' expectations is imperative as delivering online learning to them in the same way as a virtual high school could hinder their learning experiences. For students with more matured metacognition, their expectations of online learning could be substantially different from younger students. Niemi et al.'s study (2020) with students in a Finish high school have found that students often reported heavy workload and fatigue during online learning. These issues could cause anxiety and reduce students' learning motivation, which would have negative consequences on their emotional well-being and academic performance (Niemi & Kousa, 2020; Yates et al., 2020), especially for senior students who are under the pressure of examinations. Consequently, their expectations of online learning could be orientated toward having additional learning support functions and materials. Likewise, they could also prefer having more opportunities for peer interactions as these interactions are beneficial to their emotional well-being and learning performance (Gašević et al., 2013; Montague & Rinaldi, 2001). Therefore, it is imperative to investigate the differences between online learning expectations in students of different school years to suit their needs better.

Research questions

By building upon the aforementioned relevant works, this study aimed to contribute to the online learning literature with a comprehensive understanding of the online learning experience that K-12 students had during the COVID-19 pandemic period in China. Additionally, this study also aimed to provide a thorough discussion of what potential actions can be undertaken to improve online learning delivery. Formally, this study was guided by three research questions (RQs):

RQ1. What *learning conditions* were experienced by students across 12 years of education during their online learning process in the pandemic period?

RQ2. What *benefits and obstacles* were perceived by students across 12 years of education when performing online learning?

RQ3. What *expectations* do students, across 12 years of education, have for *future online learning practices*?

METHODS

Participants

The total number of K-12 students in the Guangdong Province of China is around 15 million. In China, students of Year 1–6, Year 7–9, and Year 10–12 are referred to as students of primary school, middle school, and high school, respectively. Typically, students in China start their study in primary school at the age of around six. At the end of their high-school study, students have to take the National College Entrance Examination (NCEE; also known as Gaokao) to apply for tertiary education. The survey was administrated across the whole Guangdong Province, that is the survey was exposed to all of the 15 million K-12 students, though it was not mandatory for those students to accomplish the survey. A total of 1,170,769 students completed the survey, which accounts for a response rate of 7.80%. After removing responses with missing values and responses submitted from the same IP address (duplicates), we had 1,048,575 valid responses, which accounts to about 7% of the total K-12 students in the Guangdong Province. The number of students in different school years is shown in Figure 1. Overall, students were evenly distributed across different school years, except for a smaller sample in students of Year 10–12.

Survey design

The survey was designed collaboratively by multiple relevant parties. Firstly, three educational researchers working in colleges and universities and three educational practitioners working in the Department of Education in Guangdong Province were recruited to co-design the survey. Then, the initial draft of the survey was sent to 30 teachers from different primary and secondary schools, whose feedback and suggestions were considered to improve the survey. The final survey consisted of a total of 20 questions, which, broadly, can be classified into four categories: demographic, behaviours, experiences, and expectations. Details are available in Appendix.

Procedure

All K-12 students in the Guangdong Province were made to have full-time online learning from March 1, 2020 after the outbreak of COVID-19 in January in China. A province-level

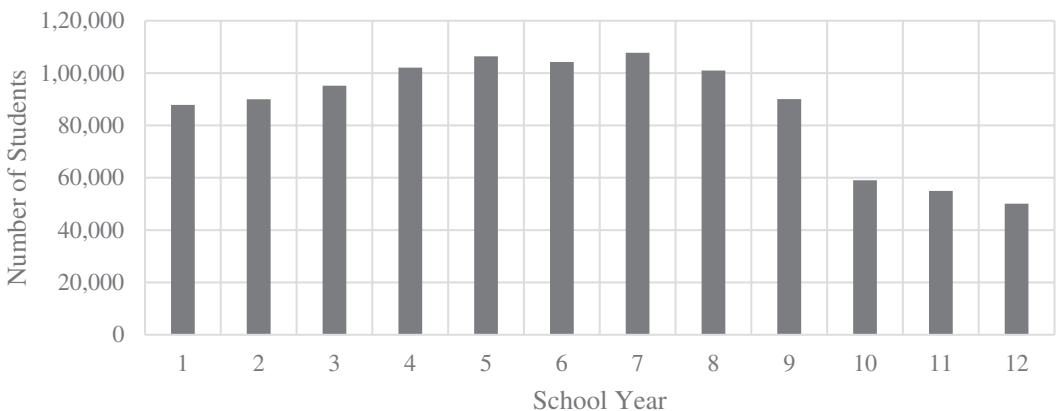


FIGURE 1 The number of students in each school year

online learning platform was provided to all schools by the government. In addition to the learning platform, these schools can also use additional third-party platforms to facilitate the teaching activities, for example WeChat and Dingding, which provide services similar to WhatsApp and Zoom. The main change for most teachers was that they had to shift the classroom-based lectures to online lectures with the aid of web-conferencing tools. Similarly, these teachers also needed to perform homework marking and have consultation sessions in an online manner.

The Department of Education in the Guangdong Province of China distributed the survey to all K-12 schools in the province on March 21, 2020 and collected responses on March 26, 2020. Students could access and answer the survey anonymously by either scan the Quick Response code along with the survey or click the survey address link on their mobile device. The survey was administrated in a completely voluntary manner and no incentives were given to the participants. Ethical approval was granted by the Department of Education in the Guangdong Province. Parental approval was not required since the survey was entirely anonymous and facilitated by the regulating authority, which satisfies China's ethical process.

Analysis

The original survey was in Chinese, which was later translated by two bilingual researchers and verified by an external translator who is certified by the Australian National Accreditation Authority of Translators and Interpreters. The original and translated survey questionnaires are available in Supporting Information. Given the limited space we have here and the fact that not every survey item is relevant to the RQs, the following items were chosen to answer the RQs: item Q3 (learning media) and Q11 (learning approaches) for RQ1, item Q13 (perceived obstacle) and Q19 (perceived benefits) for RQ2, and item Q19 (expected learning activities) for RQ3. Cross-tabulation based approaches were used to analyse the collected data. To scrutinise whether the differences displayed by students of different school years were statistically significant, we performed Chi-square tests and calculated the Cramer's V to assess the strengths of the association after chi-square had determined significance.

For the analyses, students were segmented into four categories based on their school years, that is Year 1–3, Year 4–6, Year 7–9, and Year 10–12, to provide a clear understanding of the different experiences and needs that different students had for online learning. This segmentation was based on the educational structure of Chinese schools: elementary school (Year 1–6), middle school (Year 7–9), and high school (Year 10–12). Children in elementary school can further be segmented into junior (Year 1–3) or senior (Year 4–6) students because senior elementary students in China are facing more workloads compared to junior students due to the provincial Middle School Entry Examination at the end of Year 6.

RESULTS

Learning conditions—RQ1

Learning media

The Chi-square test showed significant association between school years and students' reported usage of learning media, $\chi^2(55, N = 1,853,952) = 46,675.38, p < 0.001$. The Cramer's V is 0.07 ($df^* = 5$), which indicates a small-to-medium effect according to Cohen's (1988) guidelines. Based on Figure 2, we observed that an average of up to 87.39% students used

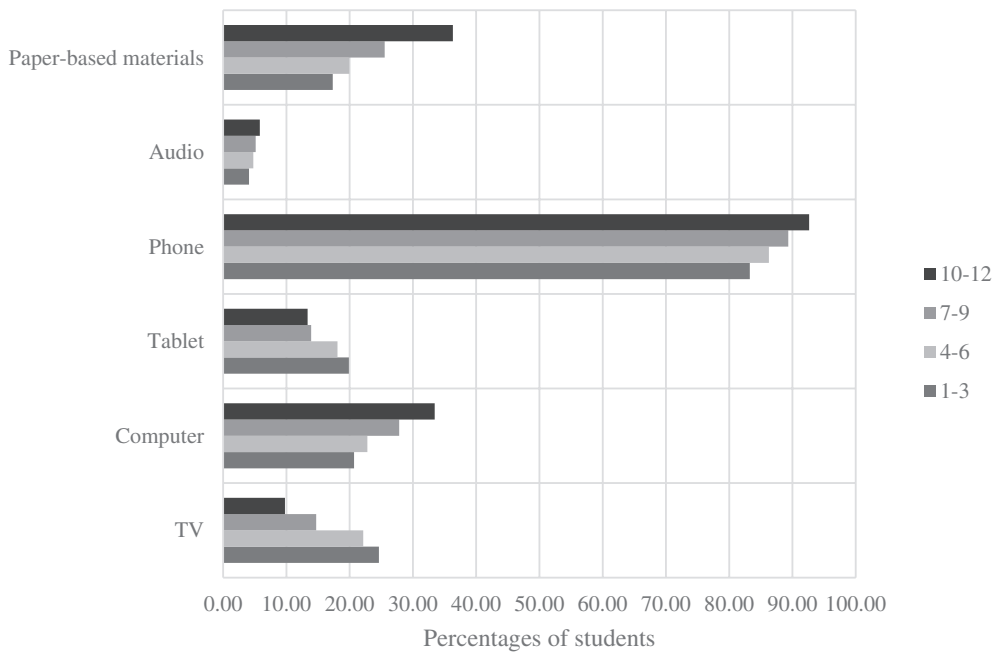


FIGURE 2 Learning media used by students in online learning

smartphones to perform online learning, while only 25.43% students used computer, which suggests that smartphones, with widespread availability in China (2020), have been adopted by students for online learning. As for the prevalence of the two media, we noticed that both smartphones ($\chi^2(3, N = 1,048,575) = 9,395.05, p < 0.001$, Cramer's $V = 0.10$ ($df^* = 1$)) and computers ($\chi^2(3, N = 1,048,575) = 11,025.58, p < .001$, Cramer's $V = 0.10$ ($df^* = 1$)) were more adopted by high-school-year (Year 7–12) than early-school-year students (Year 1–6), both with a small effect size. Besides, apparent discrepancies can be observed between the usages of TV and paper-based materials across different school years, that is early-school-year students reported more TV usage ($\chi^2(3, N = 1,048,575) = 19,505.08, p < .001$), with a small-to-medium effect size, Cramer's $V = 0.14$ ($df^* = 1$). High-school-year students (especially Year 10–12) reported more usage of paper-based materials ($\chi^2(3, N = 1,048,575) = 23,401.64, p < 0.001$), with a small-to-medium effect size, Cramer's $V = 0.15$ ($df^* = 1$).

Learning approaches

School years is also significantly associated with the different learning approaches students used to tackle difficult concepts during online learning, $\chi^2(55, N = 2,383,751) = 58,030.74, p < 0.001$. The strength of this association is weak to moderate as shown by the Cramer's V (0.07, $df^* = 5$; Cohen, 1988). When encountering problems related to difficult concepts, students typically chose to “solve independently by searching online” or “rewatch recorded lectures” instead of consulting to their teachers or peers (Figure 3). This is probably because, compared to classroom-based education, it is relatively less convenient and more challenging for students to seek help from others when performing online learning. Besides, compared to high-school-year students, early-school-year students (Year 1–6), reported much less use of “solve independently by searching online” ($\chi^2(3, N = 1,048,575) = 48,100.15, p < .001$), with a small-to-medium effect size, Cramer's $V = 0.21$ ($df^* = 1$). Also, among those approaches of seeking help from others, significantly more high-school-year students preferred

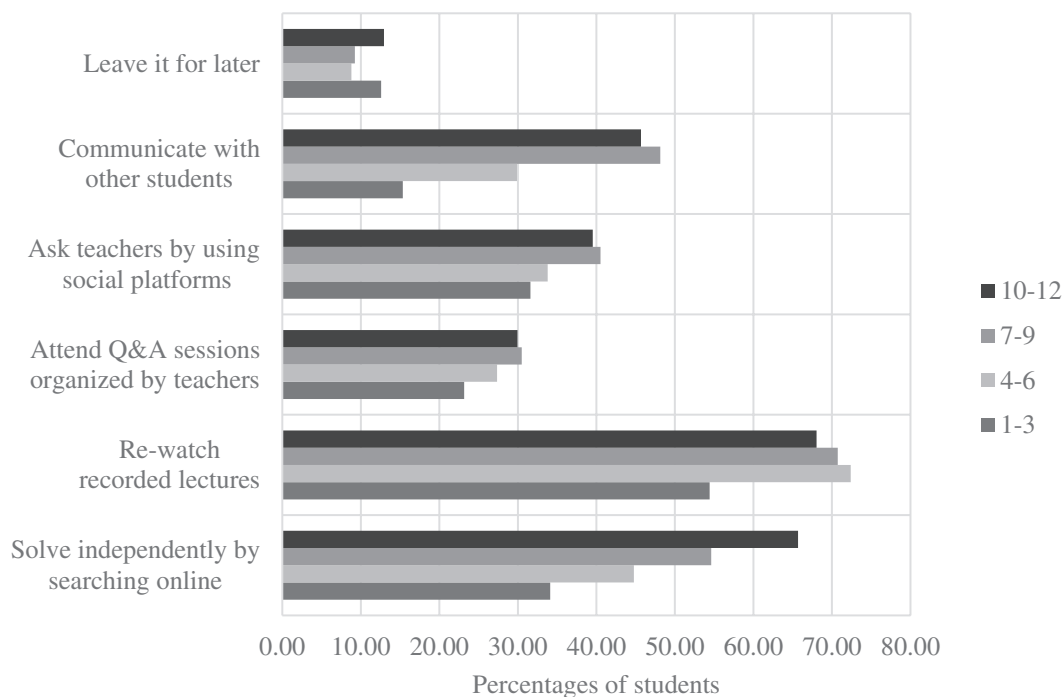


FIGURE 3 Learning approaches used by students in online learning

“communicating with other students” than early-school-year students ($\chi^2(3, N = 1,048,575) = 81,723.37, p < 0.001$), with a medium effect size, Cramer's $V = 0.28$ ($df^* = 1$).

Perceived benefits and obstacles—RQ2

Perceived benefits

The association between school years and perceived benefits in online learning is statistically significant, $\chi^2(66, N = 2,716,127) = 29,534.23, p < 0.001$, and the Cramer's V ($0.04, df^* = 6$) indicates a small effect (Cohen, 1988). Unsurprisingly, benefits brought by the convenience of online learning are widely recognised by students across all school years (Figure 4), that is up to 75% of students reported that it is “more convenient to review course content” and 54% said that they “can learn anytime and anywhere”. Besides, we noticed that about 50% of early-school-year students appreciated the “access to courses delivered by famous teachers” and 40%–47% of high-school-year students indicated that online learning is “helpful to develop self-regulation and autonomy”.

Perceived obstacles

The Chi-square test shows a significant association between school years and students' perceived obstacles in online learning, $\chi^2(77, N = 2,699,003) = 31,987.56, p < 0.001$. This association is relatively weak as shown by the Cramer's V ($0.04, df^* = 7$; Cohen, 1988). As shown in Figure 5, the biggest obstacles encountered by up to 73% of students were the “eyestrain caused by long staring at screens”. Disengagement caused by nearby disturbance was reported

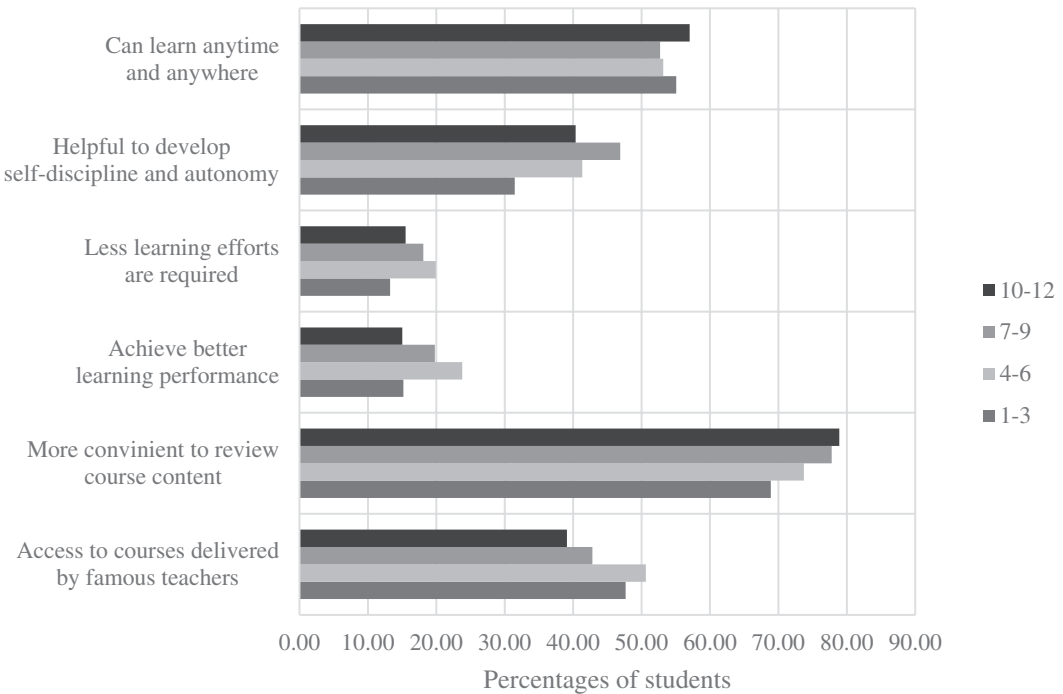


FIGURE 4 Perceived benefits of online learning reported by students

by around 40% of students, especially those of Year 1–3 and 10–12. Technological-wise, about 50% of students experienced poor Internet connection during their learning process, and around 20% of students reported the “*confusion in setting up the platforms*” across of school years.

Expectations for future practices of online learning – RQ3

Online learning activities

The association between school years and students' expected online learning activities is significant, $\chi^2(66, N = 2,416,093) = 38,784.81, p < 0.001$. The Cramer's V is 0.05 ($df^* = 6$) which suggests a small effect (Cohen, 1988). As shown in Figure 6, the most expected activity for future online learning is “*real-time interaction with teachers*” (55%), followed by “*online group discussion and collaboration*” (38%). We also observed that more early-school-year students expect reflective activities, such as “*regular online practice examinations*” ($\chi^2(3, N = 1,048,575) = 11,644.98, p < 0.001$), with a small effect size, Cramer's $V = 0.11$ ($df^* = 1$). In contrast, more high-school-year students expect “*intelligent recommendation system ...*” ($\chi^2(3, N = 1,048,575) = 15,327.00, p < 0.001$), with a small effect size, Cramer's $V = 0.12$ ($df^* = 1$).

DISCUSSION

Learning conditions—RQ1

Regarding students' learning conditions, substantial differences were observed in learning media, family dependency, and learning approaches adopted in online learning between

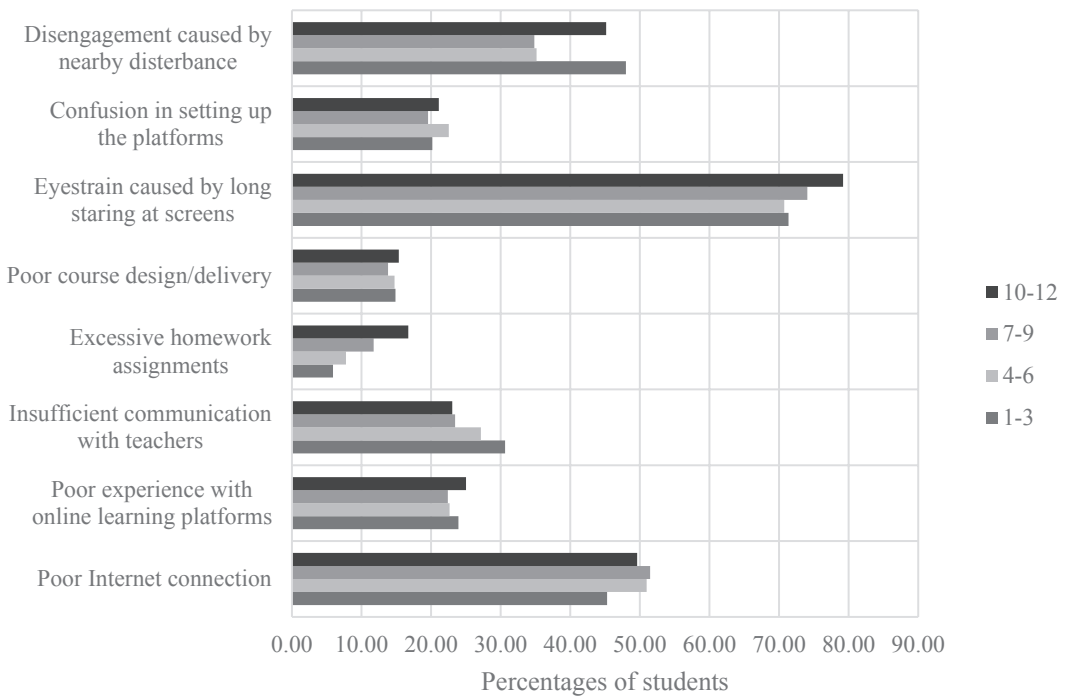


FIGURE 5 Perceived obstacles of online learning reported by students

students in different school years. The finding of more computer and smartphone usage in high-school-year than early-school-year students can probably be explained by that, with the growing abilities in utilising these media as well as the educational systems and tools which run on these media, high-school-year students tend to make better use of these media for online learning practices. Whereas, the differences in paper-based materials may imply that high-school-year students in China have to accomplish a substantial amount of exercise, assignments, and exam papers to prepare for the National College Entrance Examination (NCEE), whose delivery was not entirely digitised due to the sudden transition to online learning. Meanwhile, high-school-year students may also have preferred using paper-based materials for exam practice, as eventually, they would take their NCEE in the paper format. Therefore, these substantial differences in students' usage of learning media should be addressed by customising the delivery method of online learning for different school years.

Other than these between-age differences in learning media, the prevalence of smartphone in online learning resonates with Agung et al.'s (2020) finding on the issues surrounding the availability of compatible learning device. The prevalence of smartphone in K-12 students is potentially problematic as the majority of the online learning platform and content is designed for computer-based learning (Berge, 2005; Molnar et al., 2019). Whereas learning with smartphones has its own unique challenges. For example, Gikas and Grant (2013) discovered that students who learn with smartphone experienced frustration with the small screen-size, especially when trying to type with the tiny keypad. Another challenge relates to the distraction of various social media applications. Although similar distractions exist in computer and web-based social media, the level of popularity, especially in the young generation, are much higher in mobile-based social media (Montag et al., 2018). In particular, the message notification function in smartphones could disengage students from learning activities and allure them to social media applications (Gikas & Grant, 2013). Given these

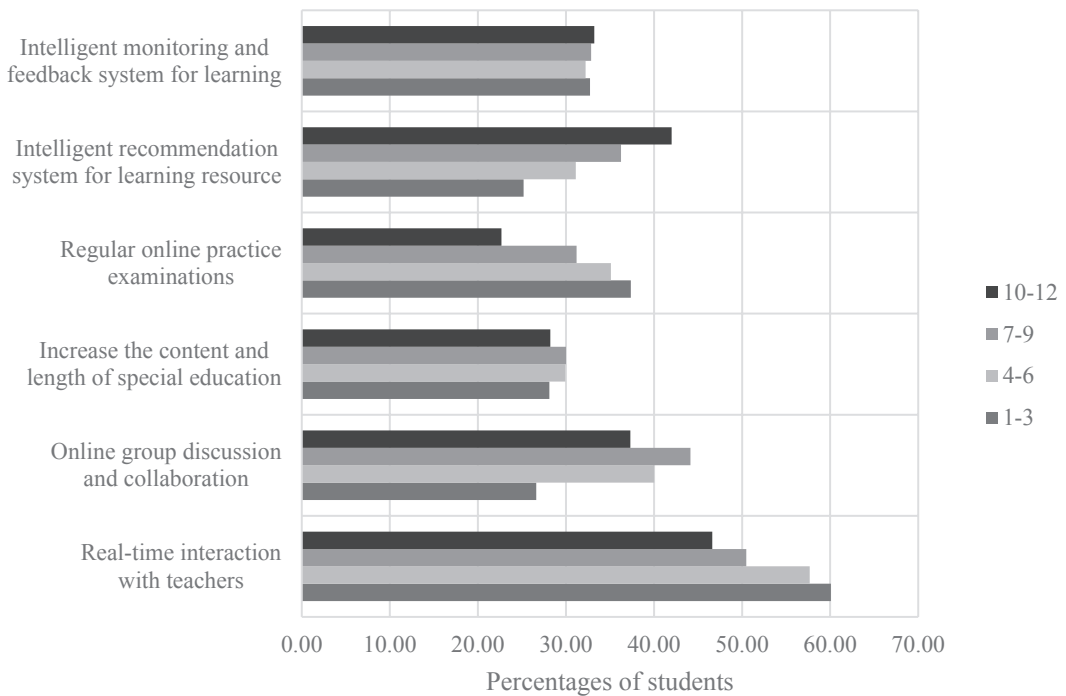


FIGURE 6 Students' expected online learning activities

challenges of learning with smartphones, more research efforts should be devoted to analysing students' online learning behaviour in the setting of mobile learning to accommodate their needs better.

The differences in learning approaches, once again, illustrated that early-school-year students have different needs compared to high-school-year students. In particular, the low usage of the independent learning methods in early-school-year students may reflect their inability to engage in independent learning. Besides, the differences in help seeking behaviours demonstrated the distinctive needs for communication and interaction between different students, that is early-school-year students have a strong reliance on teachers and high-school-year students, who are equipped with stronger communication ability, are more inclined to interact with their peers. This finding implies that the design of online learning platforms should take students' different needs into account. Thus, customisation is urgently needed for the delivery of online learning to different school years.

Perceived benefits and obstacles—RQ2

In terms of the perceived benefits and challenges of online learning, our results resonate with several previous findings. In particular, the benefits of convenience are in line with the flexibility advantages of online learning, which were mentioned in prior works (Appana, 2008; Bączek et al., 2021; Barbour, 2013; Basuony et al., 2020; Harvey et al., 2014). Early-school-year students' higher appreciation in having "access to courses delivered by famous teachers" and lower appreciation in the independent learning skills developed through online learning are also in line with previous literature (Barbour, 2013; Harvey et al., 2014; Oliver et al., 2009). Again, these similar findings may indicate the strong reliance that early-school-year students

place on teachers, while high-school-year students are more capable of adapting to online learning by developing independent learning skills.

Technology-wise, students' experience of poor internet connection and confusion in setting up online learning platforms are particularly concerning. The problem of poor internet connection corroborated the findings reported in prior studies (Agung et al., 2020; Barbour, 2013; Basuony et al., 2020; Berge, 2005; Rice, 2006), that is the access issue surrounded the digital divide as one of the main challenges of online learning. In the era of 4G and 5G networks, educational authorities and institutions that deliver online education could fall into the misconception of most students have a stable internet connection at home. The internet issue we observed is particularly vital to students' online learning experience as most students prefer real-time communications (Figure 6), which rely heavily on stable internet connection. Likewise, the finding of students' confusion in technology is also consistent with prior studies (Bączek et al., 2021; Mulienburg & Berge, 2005; Niemi & Kousa, 2020; Song et al., 2004). Students who were unsuccessfully in setting up the online learning platforms could potentially experience declines in confidence and enthusiasm for online learning, which would cause a subsequent unpleasant learning experience. Therefore, both the readiness of internet infrastructure and student technical skills remain as the significant challenges for the mass-adoption of online learning.

On the other hand, students' experience of eyestrain from extended screen time provided empirical evidence to support Spitzer's (2001) speculation about the potential ergonomic impact of online learning. This negative effect is potentially related to the prevalence of smartphone device and the limited screen size of these devices. This finding not only demonstrates the potential ergonomic issues that would be caused by smartphone-based online learning but also resonates with the aforementioned necessity of different platforms and content designs for different students.

A less-mentioned problem in previous studies on online learning experiences is the disengagement caused by nearby disturbance, especially in Year 1–3 and 10–12. It is likely that early-school-year students suffered from this problem because of their underdeveloped metacognitive skills to concentrate on online learning without teachers' guidance. As for high-school-year students, the reasons behind their disengagement require further investigation in the future. Especially it would be worthwhile to scrutinise whether this type of disengagement is caused by the substantial amount of coursework they have to undertake and the subsequent a higher level of pressure and a lower level of concentration while learning.

Expectations for future practices of online learning – RQ3

Across age-level differences are also apparent in terms of students' expectations of online learning. Although, our results demonstrated students' needs of gaining social interaction with others during online learning, findings (Bączek et al., 2021; Harvey et al., 2014; Kuo et al., 2014; Liu & Cavanaugh, 2012; Yates et al., 2020). This need manifested differently across school years, with early-school-year students preferring more teacher interactions and learning regulation support. Once again, this finding may imply that early-school-year students are inadequate in engaging with online learning without proper guidance from their teachers. Whereas, high-school-year students prefer more peer interactions and recommendation to learning resources. This expectation can probably be explained by the large amount of coursework exposed to them. Thus, high-school-year students need further guidance to help them better direct their learning efforts. These differences in students' expectations for future practices could guide the customisation of online learning delivery.

Implications

As shown in our results, improving the delivery of online learning not only requires the efforts of policymakers but also depend on the actions of teachers and parents. The following sub-sections will provide recommendations for relevant stakeholders and discuss their essential roles in supporting online education.

Technical support

The majority of the students has experienced technical problems during online learning, including the internet lagging and confusion in setting up the learning platforms. These problems with technology could impair students' learning experience (Kauffman, 2015; Mulenburg & Berge, 2005). Educational authorities and schools should always provide a thorough guide and assistance for students who are experiencing technical problems with online learning platforms or other related tools. Early screening and detection could also assist schools and teachers to direct their efforts more effectively in helping students with low technology skills (Wilkinson et al., 2010). A potential identification method involves distributing age-specific surveys that assess students' Information and Communication Technology (ICT) skills at the beginning of online learning. For example, there are empirical validated ICT surveys available for both primary (Aesaert et al., 2014) and high school (Claro et al., 2012) students.

For students who had problems with internet lagging, the delivery of online learning should provide options that require fewer data and bandwidth. Lecture recording is the existing option but fails to address students' need for real-time interaction (Clark et al., 2015; Malik & Fatima, 2017). A potential alternative involves providing students with the option to learn with digital or physical textbooks and audio-conferencing, instead of screen sharing and video-conferencing. This approach significantly reduces the amount of data usage and lowers the requirement of bandwidth for students to engage in smooth online interactions (Cisco, 2018). It also requires little additional efforts from teachers as official textbooks are often available for each school year, and thus, they only need to guide students through the materials during audio-conferencing. Educational authority can further support this approach by making digital textbooks available for teachers and students, especially those in financial hardship. However, the lack of visual and instructor presence could potentially reduce students' attention, recall of information, and satisfaction in online learning (Wang & Antonenko, 2017). Therefore, further research is required to understand whether the combination of digital or physical textbooks and audio-conferencing is appropriate for students with internet problems. Alternatively, suppose the local technological infrastructure is well developed. In that case, governments and schools can also collaborate with internet providers to issue data and bandwidth vouchers for students who are experiencing internet problems due to financial hardship.

For future adoption of online learning, policymakers should consider the readiness of the local internet infrastructure. This recommendation is particularly important for developing countries, like Bangladesh, where the majority of the students reported the lack of internet infrastructure (Ramij & Sultana, 2020). In such environments, online education may become infeasible, and alternative delivery method could be more appropriate, for example, the Telesecundaria program provides TV education for rural areas of Mexico (Calderoni, 1998).

Other than technical problems, choosing a suitable online learning platform is also vital for providing students with a better learning experience. Governments and schools should choose an online learning platform that is customised for smartphone-based learning, as the majority of students could be using smartphones for online learning. This recommendation

is highly relevant for situations where students are forced or involuntarily engaged in online learning, like during the COVID-19 pandemic, as they might not have access to a personal computer (Molnar et al., 2019).

Customisation of delivery methods

Customising the delivery of online learning for students in different school years is the theme that appeared consistently across our findings. This customisation process is vital for making online learning an opportunity for students to develop independent learning skills, which could help prepare them for tertiary education and lifelong learning. However, the pedagogical design of K-12 online learning programs should be differentiated from adult-orientated programs as these programs are designed for independent learners, which is rarely the case for students in K-12 education (Barbour & Reeves, 2009).

For early-school-year students, especially Year 1–3 students, providing them with sufficient guidance from both teachers and parents should be the priority as these students often lack the ability to monitor and reflect on learning progress. In particular, these students would prefer more real-time interaction with teachers, tutoring from parents, and regular online practice examinations. These forms of guidance could help early-school-year students to cope with involuntary online learning, and potentially enhance their experience in future online learning. It should be noted that, early-school-year students demonstrated interest in intelligent monitoring and feedback systems for learning. Additional research is required to understand whether these young children are capable of understanding and using learning analytics that relay information on their learning progress. Similarly, future research should also investigate whether young children can communicate effectively through digital tools as potential inability could hinder student learning in online group activities. Therefore, the design of online learning for early-school-year students should focus less on independent learning but ensuring that students are learning effectively under the guidance of teachers and parents.

In contrast, group learning and peer interaction are essential for older children and adolescents. The delivery of online learning for these students should focus on providing them with more opportunities to communicate with each other and engage in collaborative learning. Potential methods to achieve this goal involve assigning or encouraging students to form study groups (Lee et al., 2011), directing students to use social media for peer communication (Dabbagh & Kitsantas, 2012), and providing students with online group assignments (Bickle & Rucker, 2018).

Special attention should be paid to students enrolled in high schools. For high-school-year students, in particular, students in Year 10–12, we also recommend to provide them with sufficient access to paper-based learning materials, such as revision booklet and practice exam papers, so they remain familiar with paper-based examinations. This recommendation applies to any students who engage in online learning but has to take their final examination in paper format. It is also imperative to assist high-school-year students who are facing examinations to direct their learning efforts better. Teachers can fulfil this need by sharing useful learning resources on the learning management system, if it is available, or through social media groups. Alternatively, students are interested in intelligent recommendation systems for learning resources, which are emerging in the literature (Corbi & Solans, 2014; Shishehchi et al., 2010). These systems could provide personalised recommendations based on a series of evaluation on learners' knowledge. Although it is infeasible for situations where the transformation to online learning happened rapidly (i.e., during the COVID-19 pandemic), policymakers can consider embedding such systems in future online education.

Limitations

The current findings are limited to primary and secondary Chinese students who were involuntarily engaged in online learning during the COVID-19 pandemic. Despite the large sample size, the population may not be representative as participants are all from a single province. Also, information about the quality of online learning platforms, teaching contents, and pedagogy approaches were missing because of the large scale of our study. It is likely that the infrastructures of online learning in China, such as learning platforms, instructional designs, and teachers' knowledge about online pedagogy, were underprepared for the sudden transition. Thus, our findings may not represent the experience of students who voluntarily participated in well-prepared online learning programs, in particular, the virtual school programs in America and Canada (Barbour & LaBonte, 2017; Molnar et al., 2019). Lastly, the survey was only evaluated and validated by teachers but not students. Therefore, students with the lowest reading comprehension levels might have a different understanding of the items' meaning, especially terminologies that involve abstract concepts like self-regulation and autonomy in item Q17.

CONCLUSION

In conclusion, we identified across-year differences between primary and secondary school students' online learning experience during the COVID-19 pandemic. Several recommendations were made for the future practice and research of online learning in the K-12 student population. First, educational authorities and schools should provide sufficient technical support to help students to overcome potential internet and technical problems, as well as choosing online learning platforms that have been customised for smartphones. Second, customising the online pedagogy design for students in different school years, in particular, focusing on providing sufficient guidance for young children, more online collaborative opportunity for older children and adolescent, and additional learning resource for senior students who are facing final examinations.

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CONFLICT OF INTEREST

There is no potential conflict of interest in this study.

ETHICS STATEMENT

The data are collected by the Department of Education of the Guangdong Province who also has the authority to approve research studies in K12 education in the province.

DATA AVAILABILITY STATEMENT

The data is not openly available as it is restricted by the Chinese government.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

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APPENDIX

SURVEY ITEMS

Dimensions	Question text	Question types
Demographic	Q1. What is the location and category of your school?	Single-response MCQ
	Q2. Which school year are you in?	Single-response MCQ
Behaviour	Q3. What equipment and materials did you use for online learning during the COVID-19 pandemic period?	Multiple-response MCQ
	Q4. Other than the lecture function, which features of the online education platform have you used?	Multiple-response MCQ
	Q5. What is the longest class time for your online courses?	Single-response MCQ
	Q6. How long do you study online every day?	Slider questions
	Q8. Did you need family companionship when studying online?	Single-response MCQ
	Q10. What content does your online course include?	Multiple-response MCQ
	Q11. What approaches did you use to tackle the unlearnt concepts you had when performing online learning?	Multiple-response MCQ
	Q12. How often do you interact with your classroom in online learning?	Single-response MCQ
Experience	Q14. Regarding the following online learning behaviours, please select the answer that fits your situation in the form below.	Yes/No Questions
	Q7. Which of the following learning statuses is appropriate for your situation?	Multiple-response MCQ
	Q13. What obstacles did you encounter when studying online?	Multiple-response MCQ
	Q15. What skills do you think are developed from online education?	Multiple-response MCQ
	Q16. How satisfied are you with the following aspects of online learning?	Four-point bipolar scale
	Q17. Compared to classroom-based learning, what are the advantages of online learning?	Multiple-response MCQ
	Q18. What do you think are the deficiencies of online learning compared to physical classrooms?	Multiple-response MCQ
	Expectations	Q9. What is your preferred online classroom format?
Q19. What online activities or experiences do you expect to have that will enhance your online learning?		Multiple-response MCQ
Q20. After the COVID-19 pandemic, which type of learning would you prefer?		Single-response MCQ