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K-12 Students' Online Learning Experiences during COVID-19: Lessons from China

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Abstract Online learning has become the new educational pattern during the COVID-19 pandemic and is likely to supplement conventional schooling in the post-pandemic world. Lacking prior online learning experiences, the population of K-12 students deserves our special attention. Using purposeful sampling, this study investigated K-12 online learning experiences in China based on a large-scale survey ($N = 118,589$). Leveraging both quantitative and qualitative evidence, this study supported online learning as a flexible alternative to conventional schooling in emergency situations with a discussion of its benefits and limitations, and revealed key findings regarding K-12 students' online learning pattern, experiences, and engagement, as well as the influencing factors. The research findings can inform the future design and implementation of online learning programs in primary and secondary schools.

Keywords COVID-19, online learning, primary and secondary education, survey, China

Introduction

In January 2020, the outbreak of a novel coronavirus and its accompanying respiratory disease, COVID-19, quickly reached a critical point in China. In response, the Chinese government took several unprecedented measures to contain the spread of the virus, including the nationwide closure of schools of all

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levels. From the introduction of the Chinese Ministry of Education's "Home Study" Initiative in mid-February 2020, face-to-face instruction largely ceased and about 180 million Chinese primary and secondary school students began attending classes online, under localized online education policies specified by individual province, municipality, or autonomous region (MoE, 2020). The subsequent spread of COVID-19 around the world has seen more countries join China in closing schools and implementing online education on a massive scale. As of 13 April 2020, the world has seen over 194 nationwide school closures affect over 1.5 billion primary, lower-secondary, and upper-secondary students (UNESCO, 2020a). According to UNESCO Director-General Audrey Azoulay, "the global scale and speed of the current educational disruption is unparalleled" (UNESCO, 2020b). However, with the advancement of information and communication technologies, large-scale online learning has become a feasible means of mitigating such disruption.

Unlike post-secondary institutions and the corporate training sector, primary and secondary schools are relatively new to the concept and practice of online learning, which has historically targeted adults (Barbour & Reeves, 2009). Previously, most schools that have participated in online education have been small rural schools with insufficient educational resources (de la Varre et al., 2014; Yang et al., 2018) in which online learning was primarily used to supplement incomplete teaching materials and offer remediation for disadvantaged students (Barbour, 2019; Ronsisvalle & Watkins, 2005). Consequently, the findings in the relevant literature are context-specific and lack generalizability. Moreover, Barbour (2019) noted that the literature on K-12 online learning has largely been limited to Western countries such as the United States, and thus lacks evidence and varying levels of insight from other national and cultural contexts. Therefore, there is a gap in the literature regarding large-scale online learning in typical primary and secondary school contexts outside of the United States. This study aims to fill this gap by carrying out an empirical evaluation of K-12 students' online learning experiences in China.

The COVID-19 pandemic has seen Chinese schools nationwide move their operations online (Huang et al., 2020), and therefore provides a rare opportunity to empirically analyze and evaluate the phenomenon of online learning in primary and secondary school settings on a large scale. First, we seek to explore students' learning patterns in the online context as they are likely to differ from

the ones in traditional classrooms, and thus can lead to interesting findings regarding the sudden transition of learning modality. Second, we are keen on understanding how students perceive their online learning experiences, since such subjective perception directly affects student acceptance of and participation in online learning. Third, we are particularly interested in student engagement because lack of engagement is a persistent challenge for online learners, leading to poor online learning outcomes and retention (Buelow et al., 2018; Meyer, 2014). Fourth, to further understand the online learning patterns, experiences, and student engagement within the context of China, one needs to investigate the contextually influencing factors such as students' demography, socio-economic status, and choice of and access to educational technologies. Lastly, we plan to identify the benefits and challenges facing K-12 online learning to formulate appropriate policy recommendations in the context of COVID-19's global effects. Accordingly, the following questions guided this study:

- (1) What are the learning patterns of primary and secondary students attending online classes?
- (2) What are these students' overall perceptions of their online learning experiences?
- (3) How engaged are primary and secondary students in their online learning processes?
- (4) How do the students' patterns of, experiences of, and engagement with online learning, differ among different groups of students?
- (5) What are the benefits and challenges of online learning for primary and secondary students?

Literature Review

China's Primary and Secondary Education System

The formation of the primary and secondary education system in China between 1949 and 1960 was heavily influenced by the Soviet Union, and has many centralized features including central financing, a standard curriculum, and universal access (Pepper, 1990). It includes six years of primary school, three years of middle school, and three years of high school. While private schooling is permitted, public schools still predominate. In 2017, there were 243,500 public

schools in the Chinese mainland providing primary and secondary education to over 184 million students (MoE, 2018). According to Smith and Joshi (2016), China's emphasis on public schooling has led to higher rates of enrollment, attendance, graduation, gender parity, and college entrance compared to other developing countries. The quality of the Chinese education system has been further demonstrated by Chinese students' impressive performance in the Programme for International Student Assessment (PISA) in recent years (OECD, 2019); however, only China's most developed regions participated in PISA, so these results do not necessarily represent all Chinese students.

Since 2000, two notable trends have emerged in Chinese primary and secondary education. First, unbalanced development and massive urban migration has created a significant and widening rural-urban divide in which rural schools face tremendous challenges, including shortages of qualified teachers, educational resources, and parental involvement (Li & Ranieri, 2013; Rao & Ye, 2016). Compared to their urban peers, rural students who achieve less at school have fewer college entrance opportunities (Wang et al., 2017; Zhang et al., 2018). Second, the growing partnership between high-tech industries and urban schools has led to increased and enhanced integration of technology in these schools (e.g., mobile learning applications and learning management systems). Some of these effects have been felt in rural schools as well; national projects have seen numerous computer labs installed in order to allow rural students access to quality resources and live-stream instruction (Wang & Li, 2010). As of December 2019, 96.4% of primary and secondary schools in China had internet access, over 100 million online learning spaces had been set up for teachers and students on national platforms, and these spaces had 38 million active online users every month (MoE, 2019).

Student Engagement in Online Learning

Student engagement is an important aspect of students' online learning experiences (Dumford & Miller, 2018). Student engagement has been defined as "the quality of effort students make to perform well and achieve desired outcomes" (Sun & Rueda, 2012, p. 193). Fredricks et al. (2004) developed a tripartite model of student engagement which differentiates between students' behavioral, emotional, and cognitive engagement to reflect students' active

participation, emotional involvement, and intellectual efforts, respectively, during specific learning procedures. Other studies have shown that student engagement promotes students' academic achievement, self-esteem, motivation to learn, and satisfaction in various instructional contexts (Appleton et al., 2008; Hew, 2016; Lam et al., 2012).

Student engagement is especially important in the context of online learning because students tend to have fewer opportunities to meaningfully engage with their peers and instructors when they primarily interact over the internet (Tuckman, 2007), and lack of student engagement in online education can lead to learner isolation, passive learning, and dropping out (Banna et al., 2015; Meyer, 2014). While online learning has been found to improve certain types of social engagement such as student-teacher interaction (Dumford & Miller, 2018), the online environment can be challenging to sustain an engaging learning experience over time (Buelow et al., 2018). Although researchers have identified several factors affecting online engagement—such as prior online learning experience, self-efficacy, self-regulation, online interactions, technology quality, course resources, instructor presence, and instructional strategies (Hew, 2016; Pellas, 2014; Sun & Rueda, 2012)—most empirical findings regarding student engagement in online learning are drawn from a higher education context, not a primary and/or secondary school context.

Student Acceptance of Online Learning

The massive and sudden transition towards online learning during the COVID-19 pandemic inevitably raises the question of whether students accept it or not. According to Swanson (1988), acceptance is a critical predictor of one's appreciation of a system and predisposition to continue to use it. Our review of the literature has identified the technology acceptance model (TAM) as a theoretical framework that could help us develop and articulate an understanding of student acceptance regarding online education and integrate it into the literature. TAM conceptualizes the effective adoption of an information system as being determined by a user's intention to use the system, which is jointly predicted by their perceptions of the system's usefulness and ease of use (Davis, 1989). While TAM was most widely employed to predict the adoption of certain technologies in education (Lee & Lehto, 2013; Sánchez & Hueros, 2010; Scherer

et al., 2019), it has also been used to explain student acceptance of novel educational contexts such as e-learning (Cheung & Vogel, 2013), blended learning (Padilla-Meléndez et al., 2013), virtual learning (van Raaij & Schepers, 2008), and mobile learning (Park et al., 2011). For the online learning context, we take user's perceptions of the system's usefulness (perceived usefulness) to mean their belief that studying online will improve their academic performance, and their perceptions of its ease of use (perceived ease of use) to mean their assumption that using online learning platforms and tools will be "free of effort" (Davis, 1989, p. 320).

Methods

This study employed a large-scale online survey that collected the opinions of Chinese primary and secondary students regarding their online learning experiences. It then applied descriptive analysis, analysis of variance (ANOVA), and hierarchical regression to reveal key patterns of and relationships within student experiences with the purpose of answering the five research questions. In addition, this study also conducted observations of online classes and interviews with students and teachers to collect qualitative data for experiential interpretation of the statistical results.

Survey Participants

This study employed purposive sampling to select its survey participants. Participants were mainly from China's Hubei province for two reasons. First, the COVID-19 outbreak was first reported in its capital city, Wuhan, which makes Hubei province the region in China that has been most directly affected by the outbreak of COVID-19 and the ensuing government response. We believe that the situation in Hubei bears resemblance to other regions around the world that are presently affected by the pandemic. Second, Hubei's residents have an average per capita income, typical socio-economic structure, and slightly above-average level of education compared to national averages, making it relatively representative of China generally. We also included participants from four megacities in China (Beijing, Shanghai, Shenzhen, and Chongqing) to boost the overall number of urban students in the total sample.

A total of 118,589 students responded to the survey between March 20 and April 10, 2020. Respondents' gender, school level, school location, family residence, and learning devices used to access online education services are presented in Table 1.

Table 1 Survey Participants' Demographic Information

Category	Primary school	Middle school	High school	Total (<i>n</i>)	Percentage (%)
<i>Gender</i>					
male	42,252	11,880	7,873	62,005	52.29
female	36,534	10,559	9,491	56,584	47.71
<i>School location</i>					
Urban	57,860	15,762	14,318	87,940	74.16
Township	14,163	5,239	2,517	21,919	18.48
Rural	6,763	1,438	529	8,730	7.36
<i>Family residence</i>					
Urban	33,899	9,030	5,684	48,613	40.99
Township	27,272	8,177	6,457	41,906	35.34
Rural	17,615	5,232	5,223	28,070	23.67
<i>Learning device^a</i>					
Computer	5,525	2,967	1,207	9,429	7.95
Mobile device	52,592	15,156	12,213	79,961	67.43
Television	5,431	387	44	5,862	4.94
Mixed	15,238	4,199	3,900	23,337	19.68

Note. a. Computer includes desktop and laptops; mobile device includes mobile phones and tablets; television includes cable, IPTV, and satellite TV; mixed means students used more than one type of device during online learning.

Survey Instrument

The instrument used in this survey study was a 61-item questionnaire (see the Appendix). The questionnaire consisted of two sections. The first comprised 20 single-answer and multiple-answer questions about students' demographic information, technological choices and access, their perceptions of their own learning patterns, and the benefits and challenges of online education. The second section included 41 five-point Likert scale items which measured students' perception regarding six aspects of online learning, namely, workload,

social interaction, student engagement, student acceptance, self-management, and learner satisfaction. Among these, the items measuring student engagement were adapted from the instrument validated by Sun and Rueda (2012) and were sub-divided into behavioral, emotional, and cognitive engagement, and the items measuring student acceptance were informed by the TAM literature (Davis, 1989; Venkatesh & Bala, 2008) and sub-divided into perceived usefulness, ease of use, and intent of continuous usage. The distribution of survey items is shown in Table 2.

Table 2 The Constructs, Structure, Reliability, and Validity Results of the Questionnaire

Constructs	Item	Cronbach's α	Factor Loading	CR	AVE	$\sqrt{\text{AVE}}$
Basic information	1–20	n/a ^a	n/a	n/a	n/a	n/a
Workload	21–25	0.880	0.731–0.809	0.881	0.597	0.773
Social interaction	26–30	0.908	0.670–0.901	0.907	0.665	0.815
Student engagement						
Behavior	31–33	0.883	0.795–0.879	0.885	0.721	0.849
Emotional	34–38	0.948	0.788–0.938	0.950	0.793	0.891
Cognitive	39–43	0.927	0.780–0.911	0.927	0.719	0.848
Student acceptance						
Perceived usefulness	44–47	0.948	0.877–0.928	0.948	0.820	0.906
Perceived ease of use	48–50	0.891	0.795–0.899	0.892	0.733	0.856
Intent of continual usage	51–53	0.907	0.835–0.935	0.909	0.769	0.877
Self-management	54–56	0.900	0.843–0.892	0.901	0.752	0.867
Learner satisfaction	57–61	0.909	0.787–0.858	0.909	0.668	0.817

Note. a. n/a = not available. Items 1–20 collected basic information rather than measuring latent constructs, thus were not subjected to reliability and validity analyses.

Reliability Analysis

The study instrument's reliability was measured by Cronbach's α coefficient, which reflects the internal consistency among the survey items. According to Nunnally (1978), a Cronbach's α coefficient larger than 0.7 suggests that an instrument is highly reliable. In this study, the overall Cronbach's α coefficient for the 41 items in the second section of the questionnaire was 0.959. Moreover, Table 2 shows that the α coefficients for all latent constructs were between 0.88 (workload) and 0.948 (emotional engagement and perceived usefulness), indicating a high degree of reliability.

Validity Analysis

The questionnaire's construct validity is determined by both its convergent and its discriminant validity (Campbell & Fiske, 1959). Convergent validity is the degree of shared variance of the indicators measuring a potential construct and can be calculated through the standardized factor loadings of the items, composite reliability (CR), and average variance extracted (AVE). According to Bagozzi and Yi (1988), acceptable convergent validity requires a factor loading larger than 0.7, a CR larger than 0.6, and an AVE larger than 0.5. As shown in Table 2, the questionnaire met such requirements and thus can be deemed as having suitable convergent validity.

Discriminant validity is the degree to which the measures of different constructs are unrelated. According to Fornell and Larcker (1981), discriminant validity can be proven if the square root of the AVE value of a potential construct is larger than its correlation coefficients with other constructs. The $\sqrt{\text{AVE}}$ values for all of the questionnaire's constructs range between 0.773 and 0.906 and are all larger than the relevant correlation coefficients. As a result, the questionnaire's discriminant validity is suitable as well.

Statistical Analysis Methods

The three major types of statistical analysis methods used in this study were descriptive analysis, one-way ANOVA, and hierarchical regression. Descriptive statistics such as mean, standard deviation, and percentage frequency presented an overview of K-12 online learning in China in terms of learning patterns, experiences, and engagement with identification and ranking of perceived benefits and challenges. One-way ANOVA was conducted to determine the impact of student characteristics (e.g., gender, grade level, school location, and use of devices) on perceived learning experience. Although the assumption of normality was violated with Likert-scale survey data, the selection of ANOVA is justifiable in this study, since it is robust against non-normality and heterogeneity of variances if the sample size is large (Feir-Walsh & Toothaker, 1974).

To further understand the factors that contribute to student engagement in online learning, we conducted hierarchical regressions with the four types of learning engagement (behavioral, emotional, cognitive, and overall engagement)

as outcome variables. Two groups of variables were entered into the regression models successively as predictor variables using the forward selection procedure. The first group consisted of student characteristics variables and the second group comprised variables measuring students' perceptions and acceptance of online learning experiences (e.g., workload, social interaction, self-management, learner satisfaction, perceived usefulness, perceived ease of use, and intent of continual usage).

Observation and Interview Guides

To acquire in-depth understanding of the online learning phenomenon in China, we selected 34 online classrooms as cases and used virtual observation and interviews to collect qualitative data regarding students' practice in and attitude towards online learning. The selected cases were from seven primary schools, 11 middle schools, and 13 high schools, and covered nine subjects: mathematics (9), English (5), physics (5), geography (4), biology (4), Chinese (2), politics (2), chemistry (2), and music (1). The online case studies lasted for two weeks during March 2020 and resulted in a collection of virtual ethnographic field notes (130,000 words) as the main data source for qualitative analysis.

Considering online class as a social situation, the observation guide focused on the three key social elements proposed by Spradley (1980): actors (e.g., teacher, student, and parent), activities (e.g., lecture, quiz, question and answer, assignment, management, and assessment), and places (e.g., online learning platforms, communication software, discussion forums, teacher end, student end, online, and offline). The semi-structured interviews aimed to have students and teachers describe and reflect upon their own online learning/teaching experiences, and were guided by the following questions: (1) What is your overall opinion of online learning, and why? (2) What were the most memorable events occurred during online learning? (3) How did you use the online learning platforms and tools, and what do you think of them? (4) What is your preference between online and face-to-face class, and why? (5) Please identify two major benefits and challenges for online learning, and provide rationale. In keeping the interpretivist and naturalistic tradition of qualitative analysis, the observation and interview guides in this study were flexible enough for the researchers to notice unexpected empirical evidence and collect open-ended responses.

Results

Online Learning Patterns

The survey results revealed several interesting patterns regarding participants' online learning experiences (Figure 1). First, the average length of an online class was found to increase along with students' grade level. Online classes were shorter than usual in primary schools, 39.71% of primary students reported having class sessions lasting less than 30 minutes. In contrast, 58.67% of middle school and 81.19% of high school students reported class sessions lasting longer than 40 minutes (Figure 1a). Second, mobile devices such as smartphones and tablets were widely used for online learning, and 67.43% of the participants considered these to be their main learning devices. Surprisingly, only 7.95% of the participants used computers to study, and 4.94% still relied on televisions to receive online instruction. In addition, about one-fifth of the participants used multiple devices while learning (Figure 1b).

Moreover, the format of online instruction was found to be primarily lecture-based rather than self-directed or social-collaborative. The participants primarily attended live lectures online; only 32.06% of students engaged in self-study and 8.39% reported having participated in collaborative learning (Figure 1c). There were two main types of live lecture: unified lectures organized by schools to serve multiple classes simultaneously, and personal lectures which instructors delivered to their own classes. The former type of online lecture (59.55%) was slightly more popular than the latter type (50.6%). Figure 1c shows that the participants engaged in a variety of activities during online learning, including physical exercise (34.39%), online examinations (28.87%), themed class meetings (17.55%), and flag raising ceremonies (14.29%). Lastly, the participants' online learning experiences seemed to lack social interaction elements, the most frequent type of interaction was attendance taking (64.22%), followed by online communication by text or video/audio call. Technologies such as pop-up quizzes and real-time comments introduced learner-interface interactions to the online learning process, but less than 20% of the participants reported engaging in these. In total, less than 9% of the participants engaged in online interactions such as group discussion and class voting (Figure 1d).

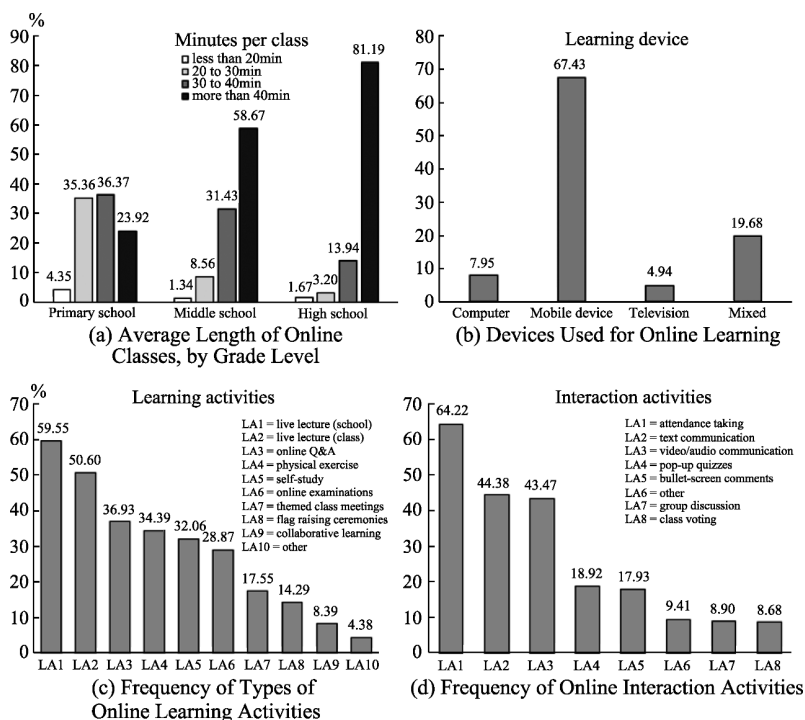


Figure 1 Online Learning Patterns of Study Participants

Online Learning Experiences

Overall, the participants expressed positive opinions of their online learning experiences: Their ratings of their perceived social interaction ($\bar{x} = 3.407$), self-management ($\bar{x} = 3.398$), and learner satisfaction ($\bar{x} = 3.532$) were above the neutral point in a five-point Likert scale, indicating an overall favorable evaluation; and their rating of perceived workload in online classes ($\bar{x} = 2.697$) was below neutral, also in favor of a positive learning experience. Further examination of specific item ratings revealed that the participants were especially satisfied with their teachers' online teaching methods ($\bar{x} = 3.72$) and the assistance they received from their parents ($\bar{x} = 3.69$), but seemed to take a neutral stance on whether they would communicate with peers on learning content ($\bar{x} = 3.11$).

We also used ANOVA to examine the impact of student characteristics (including the variables of gender, grade level, school location, and use of devices) on four types of perceived learning experiences. The key results are listed in Table 3. Due to the large sample size in this study, the statistical

significance of different variables can be obtained with only trivial differences between groups. As a result, partial eta squared (η_p^2) values greater than 0.01 were highlighted in Table 3 to indicate which characteristics had a discernible effect size. Table 3 shows that the participants' grade level had the largest impact on their perceived online learning experiences: High school students reported the heaviest workload, poorest self-management, and least learner satisfaction, whereas middle school students rated their self-management and learner satisfaction very positively. The impact of school location reflects the vast educational inequities in China, as the best and worst online learning experiences were perceived by students in urban schools and rural schools, respectively.

Table 3 Impact of Student Demographics on Four Perceptions of Online Learning Experiences ($N = 118,589$)

Characteristic		Workload	Social interaction	Self-management	Learner satisfaction
Gender	Male	2.708	3.409	3.381	3.525
	Female	2.686	3.405	3.428	3.541
	η_p^2	0.000***	0.000	0.000***	0.000***
Grade level	Primary school	2.615	3.413	3.405	3.565
	Middle school	2.753	3.439	3.515	3.602
	High school	2.999	3.342	3.217	3.295
	η_p^2	0.028***	0.001***	0.013***	0.02***
School location	Urban	2.670	3.415	3.408	3.549
	township	2.764	3.398	3.378	3.493
	Rural	2.801	3.355	3.349	3.464
	η_p^2	0.003***	0.000***	0.001***	0.002***
Learning device	Computer	2.633	3.413	3.450	3.598
	Mobile	2.729	3.400	3.388	3.513
	Television	2.616	3.034	3.316	3.478
	Mixed	2.637	3.447	3.432	3.587
	η_p^2	0.003***	0.001***	0.001***	0.003***

Note. *** $p < .001$, η_p^2 larger than 0.01 are marked bold to indicate a discernible effect size.

In addition, television users suffered from relatively poor social interaction and self-management and reported the lowest levels of satisfaction with their online learning experiences. The participants who used computers or a mix of devices reported more satisfying online learning experiences. Lastly, female participants rated their online learning experiences slightly higher than their male

counterparts, however, this difference was not as substantial as those between other characteristics mentioned above.

Online Learning Engagement and Influencing Factors

Table 4 presents the key descriptors of online learning engagement as measured by the engagement scale. With both average rating ($\bar{x} = 3.385$) and interquartile range (3–3.77) above 3 in a five-point Likert scale, the overall student engagement in online learning is deemed as above average. In particular, the participants seemed more behaviorally engaged in online learning ($\bar{x} = 3.631$) than they were emotionally ($\bar{x} = 3.237$) or cognitively ($\bar{x} = 3.386$) engaged. Emotional engagement featured the largest standard deviation of these three variables ($SD = 0.82$), indicating greater differences in individuals' emotional involvement in online learning. Specifically, the survey items “I complete various tasks on time” ($\bar{x} = 3.75$) and “I follow the rules of the online class” ($\bar{x} = 3.64$) received the highest average ratings, whereas the items “I feel happy when taking online classes” ($\bar{x} = 3.23$) and “I like taking online classes” ($\bar{x} = 3.12$) were rated the lowest.

Table 4 Key Results of the Hierarchical Regression Analysis Predicting Online Learning Engagement ($N = 118,589$)

Measure	Overall engagement	Behavioral engagement	Emotional engagement	Cognitive engagement
Descriptors				
Mean	3.385	3.631	3.237	3.386
Standard deviation	0.669	0.728	0.82	0.737
Interquartile range	3–3.77	3–4	3–3.8	3–4
Hierarchical model summary				
R^2 (Model 1 ^a)	0.022***	0.020***	0.027***	0.01***
R^2 (Model 2 ^b)	0.671***	0.405***	0.565***	0.548***
R^2 change	0.649***	0.385***	0.538***	0.547***
Standardized coefficient ^c				
Social interaction	0.284	0.319	0.145	0.381
Perceived usefulness	0.438	0.234	0.460	0.320
Perceived ease of use	0.257	0.213	0.256	0.195

Note. a. Model 1 includes five demographic variables (gender, grade level, school location, family residence, learning devices); b. Model 2 includes five additional variables (workload, social interaction, perceived usefulness, perceived ease of use, intent of continual usage); c. only standardized coefficients larger than 0.1 are displayed; *** $p < .001$.

Table 4 also shows the key results of the hierarchical regression analysis predicting four types of online learning engagement, with student characteristics being the first block of predictors and the variables of online learning experiences and acceptance being the second block of predictors. To avoid multicollinearity, the predictors “management” and “satisfaction” were excluded from the final regression models due to their high correlations with the predictors measuring online learning acceptance (for all values, $r > 0.7$).

As seen in Table 4, when the variables of student characteristics were entered alone, they predicted only 2.2% of the variance in overall online learning engagement (adjusted $R^2 = 0.022$, $p < .001$), yielding a significant but weak predictive effect. However, when five additional variables regarding the participants' perceptions of their experiences and acceptance of online learning were added, they predicted 67.1% of the total variance, an increase of 64.9% ($\Delta R^2 = 0.649$, $p < .001$). Similar results were found in regression models predicting behavioral, emotional, and cognitive engagement. Student characteristics did not contribute consequentially to the variances of the three types of engagement ($R^2 = 0.02$, 0.027 , and 0.01 , respectively) whereas the variables measuring the participants' online experiences and their acceptance of online learning yielded greater predictive power ($\Delta R^2 = 0.385$, 0.538 , and 0.538 , respectively). Interestingly, while behavioral engagement was rated the highest by the participants, it was the most poorly predicted type of engagement with the same set of predictors.

Moreover, the variables social interaction, perceived usefulness, and perceived ease of use were found to be key predictors of online learning engagement. Each had standardized regression coefficients larger than 0.1. Of these, the perceived usefulness of online learning contributed most to predicting the participants' overall learning engagement ($\beta = 0.438$), especially their emotional engagement ($\beta = 0.46$). However, the participants' perceived social interactions failed to induce strong emotional engagement ($\beta = 0.145$) and tended to have greater influence on their behavioral ($\beta = 0.319$) and cognitive engagement ($\beta = 0.381$). The perceived ease of use of learning platforms and tools contributed moderately to all four types of online learning engagement, and less variation was found in its predictive power.

Benefits and Challenges of Online Learning

We also identified several benefits and challenges the participants faced when

learning online based on our observations of online classes and interviews with students and teachers prior to the survey. Figure 2 displays the percentages of students who agreed or strongly agreed with the proposed benefits and challenges.

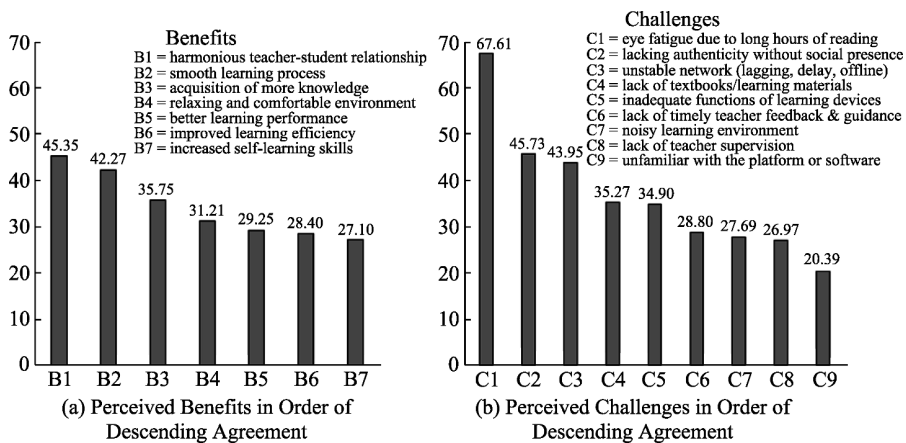


Figure 2 Percentage of Students Who Agreed with the Proposed Benefits and Challenges of Online Learning

According to Figure 2a, improved teacher-student relationships were the most widely recognized benefit of online learning found in this study. Teaching from home made many teachers adjust their teaching strategies to dedicate greater efforts to increase student engagement and learning motivation. One teacher commented that “teaching online makes me feel like an awkward influencer eager to entertain my audience.” Teachers also tended to reveal more of their personal lives when teaching from home: One physics teacher taught vaporization in his own kitchen, and one music teacher invited her family to perform as a trio when teaching certain concepts regarding voice. About 42.27% of the participants indicated that their online learning processes were smoother than they were in traditional classrooms, explaining that “online classes are better-organized and timed” and “the online learning platform makes preview, review, and assignment submission much easier.” About one-third of the students enjoyed the more relaxing atmosphere of the online learning environment and acknowledged its effects on their improved learning outcomes, self learning skills, and learning efficiency.

Figure 2 also shows that the most widely experienced challenges are physiological rather than pedagogical or technical. About two-thirds of all participants (67.61%) reported eye fatigue, and further analysis revealed that high school students reported the most eye fatigue issue (73.9%) compared with middle and primary school students (63.78% and 67.32%, respectively), which is not surprising, as they reported the heaviest workload. The other two common challenges students faced were a sense of inauthenticity (45.73%) and an unstable network connection (43.95%). While live-streamed instruction aimed to replicate authentic face-to-face learning experiences, network issues constantly reminded the participants of the differences between the two. The unrealistic feeling was worsened in unified online classes organized by schools, since social presence in those classes was almost non-existent with newly appointed teachers and unfamiliar peers from other classes. As a result, some participants still had difficulty adjusting to this new mode of instruction even after two months' experience. On the other hand, only 20.39% of the participants identified their unfamiliarity with technology as a challenge to their online learning processes.

Discussion

The survey results provide tentative answers to our five research questions. While the online learning environment has the potential to transform traditional K-12 classrooms with redesigned instructional approaches (Means et al., 2010), our study revealed that Chinese primary and secondary students' online learning patterns are still largely teacher-centered and lecture-based, mimicking the face-to-face learning paradigm. The fact that attendance taking and real-time chatting were the prevailing types of teacher-student interaction and more dynamic, technology-based forms of online interaction (asynchronous discussion, pop-up quizzes, and bullet-screen comments, etc.) were less common indicates that Chinese schools are not making sufficient use of collaborative affordance of online tools (Abrami et al., 2011; Hernández-Sellés et al., 2019). This may be because most Chinese teachers were underprepared for the sudden wholesale move to online education, or because instructional reforms that emphasize self-regulated online learning present challenges for many students (Cho & Shen, 2013). However, online learning is relatively flexible in terms of class length, use of learning devices, which can accommodate differences in students' grade level,

learning contexts, and family socio-economic status (Huang et al., 2020).

Overall, the participants reported positive perceptions of their online learning experiences. This indicates that they are gradually adapting to this new mode of education. This study found that students' gender does not have a significant effect on student behavior, motivation, and achievement—a result corroborated by the literature (e.g., Yukselturk & Bulut, 2009). It also found that students' grade level had the largest impact on their perceptions of online learning and that high school students had the most negative perceptions—a finding corroborated by Yang and Chang's (2009) discovery that because high school students are transforming their personal epistemologies while in school, they tend to have rather conservative and negative opinions of online learning's effectiveness, difficulty, and appropriateness. Furthermore, the survey results confirm that the regional inequities in China's education system (Golley & Kong, 2016; Yang et al., 2014) extend to the context of K-12 online education, where the lack of access to digital resources, internet self-efficacy, and family support for rural students creates a large rural-urban divide in the quality of education students receive (Li & Ranieri, 2013).

The survey results also provide insights into student engagement with online learning. Similar to research findings from studies of higher education contexts (e.g., Dumford & Miller, 2018; Junco et al., 2013), this study found that the online environment seemed to support student engagement at the primary and secondary school levels to varying degrees. The participants rated their behavioral engagement much higher than their cognitive and emotional engagement, which indicates that they participated in online classes with less affective commitment and intellectual effort. According to Pellas (2014), low levels of internet self-efficacy and students' metacognitive skills may explain these differences. The fact that student characteristics could only predict student engagement to a limited extent in this study is not entirely surprising, since learning and motivational factors have been found to have more influence on student engagement than student demography in other studies (Pellas, 2014; Sun & Rueda, 2012). By identifying students' online interactions, perceived usefulness, and perceived ease of use as key predictors of student engagement, this study highlights the importance of social learning and motivational beliefs to engaging online learning experiences. Emotional engagement was best predicted by perceived usefulness and yet least well predicted by online interaction, which

suggests that motivational beliefs matter more than learning experiences when attempting to induce positive feelings and keep students engaged.

We concur with previous studies' assertions that the biggest benefit of online education is its capacity to ensure the continuity of education in emergency situations (e.g., Huang et al., 2020). We also noticed that the sudden, wholesale transition to online education has revealed several unexpected advantages for students. For instance, the physical separation of teachers and students seemed to alter their social identities and generate more harmonious relationships; teachers were more likely to disclose personal information to their students, foster intimacy and responsiveness, and thus enhance teacher-student relationships (Song et al., 2016). Online learning has also been praised for the smooth-running and relaxing atmosphere it creates through its structure and the anonymity it provides (Barr, 2017; Dillenbourg et al., 2018), findings which were corroborated by our interviews with students. Lastly, a small proportion of the participants reported improved learning outcomes (e.g., knowledge acquisition, academic performance, and self-learning skills), which was consistent with meta-analyses in the literature (Means et al., 2010). However, we caution against viewing these benefits as proof of online learning's superiority, as we found that the participants also received greater assistance and supervision from their parents when studying at home, which substantially extended their learning time and threw student participation into question in some cases.

Furthermore, this study revealed that students face several challenges when learning online: eye fatigue, a lack of social interaction, and technical problems. These findings are also corroborated by the literature: For example, reading digital content is known to induce higher eye fatigue (Jeong, 2012; Kang et al., 2009). However, eye fatigue can be reduced with proper ergonomic design, such as ambient illumination, primary background color, and effective luminance contrasts (Greco et al., 2008; Lin & Huang, 2013). The participants' complaint regarding the lack of social interaction is an anticipated and persistent challenge for online learning environments (Luo et al., 2018).

It also found that, despite the rapid development of educational technology infrastructure and applications in China (Wang & Li, 2010), technical issues were still common and adversely affected students' online learning experiences. The participants also valued network and platform stability more than functionality and ease of use, which indicated that students gradually familiarized themselves

with online learning platforms over time and could develop strategies to compensate for functionality deficiencies with time, but that stability issues such as an inconsistent network or system collapse would irremediably disrupt the online learning process.

Conclusion

Online learning that has arisen during this unprecedented public health emergency, is predicted to persist in the post-pandemic world. This study aimed to extend our collective understanding of this new norm in education by investigating the online learning experiences of primary and secondary school students in China who have participated in the country's "Home Study" Initiative since mid-February 2020. Overall, its results support the feasibility and usefulness of online learning as a flexible alternative to conventional schooling at the primary and secondary levels, and revealed several interesting findings regarding student characteristics, social interaction, motivational beliefs, and online technologies in relation to online learning experiences.

Practical Implications

Several implications for facilitating K-12 online learning can be drawn from this study. First, high school and rural students deserve our special attention due to below par online learning experiences. Second, teachers should fully utilize the affordance of online technologies to promote social interaction and student-centered learning during the online learning process. Third, the perceived usefulness of online learning should be enhanced by means of education, media publicity, and empirical data to dissolve the stereotype of online learning as ineffective and inferior. Fourth, when developing online learning platforms, the priority should be given to system stability and ergonomic design in addition to functionality and ease of use.

Limitations and Future Research

There are three chief limitations in the present study. First, the results of this study were based on survey data which were self-reported by K-12 students.

Survey data are known to suffer a greater risk of measurement errors (Coughlan et al., 2009), and such risk was aggravated in this study with many of the survey participants being children. Second, while this study boasts a large sample size, the representativeness of the sampled participants can be further enhanced, since the current sample is biased towards the student population in Hubei province and thus undermines the generalizability of research findings. Third, most survey data were collected at the end of March 2020, when the students had participated in online learning practices for only a short period of time (about six weeks). As a result, the research finding might not reflect changes in students' perception of and attitude towards online learning over time. Accordingly, future researchers should consider using empirical data in addition to survey results to investigate the phenomenon of online learning, such as learning analytics and test scores. Moreover, we recommend conducting longitudinal studies with a more representative student population to boost the credibility and generalizability of research findings.

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Appendix Translated Questionnaire Items

Part 1: Basic information

1. Your gender is

- Male Female

2. Your grade is

- First grade Second grade Third grade Fourth grade Fifth grade Sixth grade Seventh grade Eighth grade Ninth grade Tenth grade 11th grade 12th grade

3. Your grade level is

- Primary school Middle school High School

4. Your family residence is

- Urban Township Rural

5. Your school location is

- Urban Township Rural

6. Your school type is

- Urban school Township school Rural school Teaching site

7. Have you participated in online courses in the past?

- Never Seldom General Often Always

8. How is your family's financial condition?

- Very poor Relatively poor Average Relatively rich Very rich

9. Which of the following situations do you belong to? (multiple)

- Left-behind students Migrant students Children of frontline medical staff

Children of frontline non-medical personnel Does not belong to the above situations

10. Who is mainly urging and guiding you to learn during you-participation in online learning?

○ Father/mother ○ Grandparents/grandparents ○ Other relatives ○ Neighbors ○ Unattended ○ Other _____

11. How many online lessons do you have every day?

○ One ○ Two ○ Three ○ Four ○ Five ○ Six ○ Seven ○ Eight ○ Nine ○ Ten ○ 11 ○ 12 ○ Greater than 12

12. What is the average time of each online learning class?

○ 20 minutes or less ○ 20 to 30 minutes ○ 30 to 40 minutes ○ 40 minutes or more

13. What is your learning device? (multiple)

○ Desktop PCs ○ Laptop ○ Tablet PC ○ Phone ○ TV (Cable TV/IPTV/ Satellite TV)

14. Your Internet access is (multiple)

○ WIFI ○ Mobile Internet data ○ Wired network ○ Satellite TV

15. The online learning tools or platforms you use are (multiple)

○ QQ ○ WeChat ○ DingDing ○ Tencent Classroom/Conference ○ Homework Help ○ Ape Tutorial ○ Learn and think ○ Rain Classroom ○ Superstar Learning ○ ZOOM ○ CCTalk ○ Classin ○ Bilibili ○ HuiChang ○ Douyin ○ Everyone connects ○ ZhiXue Net ○ Education Cloud platform ○ Other _____

16. Your online learning course include (Multiple)

○ Chinese ○ Mathematics ○ English ○ Science ○ Biology ○ Physics ○ Chemistry ○ History ○ Geography ○ Music ○ PE ○ Art ○ Information Technology ○ Morality and law ○ Life and safety education ○ Mental health education ○ Integrated practical activities ○ Special course for epidemic prevention ○ Patriotism Education ○ Others _____

17. The online activities you participate in include (multiple)

○ Live instruction (school) ○ Live instruction (class) ○ Self-study ○ Collaborative learning ○ Online Q&A ○ Physical exercise ○ Online examinations ○ Themed class meetings ○ Flag raising ceremonies ○ Other _____

18. The online discussion activities you participated in include (multiple)

○ Attendance taking ○ Text communication ○ Video/audio communication ○ Real-time video comments ○ Class voting ○ Pop-up quizzes ○ Group discussion ○ Other _____

19. The types of online assignments you submit include (multiple)

○ Directly submit by tools ○ Take a picture and submit ○ Voice homework ○ Video homework ○ Group cooperative work ○ Parent-child work ○ Experimental work ○ Other _____ ○ No homework

20. How is your homework graded?

- Platform automatically graded
- Teacher graded online
- Self/parent graded
- Peer graded online
- Not graded

Part 2: Likert-Scale Evaluation

Workload

21. The number of homework is relatively large.
22. It is difficult to finish the homework.
23. There are not enough materials needed to finish the homework.
24. It is not convenient to submit homework.
25. The teacher did not provide timely feedback on the homework.

Social interaction

26. I will discuss about learning content with my classmates.
27. I will answer classmates' questions.
28. I will share my thoughts with my classmates.
29. I will ask the teacher questions.
30. I will answer the teacher questions.

Behavior engagement

31. I can comply with all the requirements during online learning.
32. I can complete all tasks on time during online learning.
33. I will actively check my homework during online learning.

Emotional engagement

34. I like online learning.
35. I am very excited about the various activities in the online learning.
36. Attending online learning is fun.
37. I am very interested in various activities in the online learning.
38. I feel very happy during online learning.

Cognitive engagement

- 39. I will study hard at home even if the teacher and parents do not require.
- 40. I will try to look for some course-related information from the Internet, TV, books, etc.
- 41. When I am reading course materials, I will ask myself questions to make sure what it is about.
- 42. I will read more extra materials to deepen my understanding of the knowledge learned in the online class.
- 43. When I encounter knowledge that I don't know during online learning, I will try to figure it out.

Perceived usefulness

- 44. Online learning can make me have a better learning performance.
- 45. Online learning allows me to learn more knowledge.
- 46. Online learning can improve my learning efficiency.
- 47. Online learning is very helpful to my study.

Perceived ease of use

- 48. I think the design of the online learning platform or software is clear and understandable.
- 49. I think the online learning platform or software are easy to use.
- 50. I can easily use online learning platforms or software to carry out learning activities.

Intent of continual usage

- 51. I am willing to learn online.
- 52. I hope I could use more online methods to study.
- 53. I hope I can continue to learn online in the future.

Self-Management

- 54. I can arrange my study time reasonably.
- 55. I will maintain a good mood and patience during online learning.

56. I can make a self-evaluation of my study.

Learner Satisfaction

57. I am satisfied with online learning in general.

58. I am satisfied with the teacher's teaching.

59. I am satisfied with the platforms and tools used for online learning.

60. I am satisfied with my parents' support and help.

61. I am satisfied with my online learning performance.