"I was afraid, but now I enjoy being a streamer!": Understanding the Challenges and Prospects of Using Live Video Streaming for Online Education

XINYUE CHEN, Department of Information Management, Peking University, China
SI CHEN, School of Information Sciences, University of Illinois Urbana-Champaign, USA
XU WANG, Human-Computer Interaction Institute, Carnegie Mellon University, USA
YUN HUANG, School of Information Sciences, University of Illinois Urbana-Champaign, USA

The outbreak of COVID-19 has led to a sharp transition from offline to online education in many countries and areas. This transition heightens the intensity of existing challenges of online education, such as student attendance and education equality. During this time of uncertainty, the vast disparities in teachers' online experience and technical backgrounds, students' education level and their families' economic status, and schools' support, further pose new challenges to teachers and students. In this work, we study how Chinese teachers and students addressed challenges during this transition. We interviewed 15 teachers and 18 students from diverse backgrounds at varying education levels (K-12 and college). Our work makes timely and new contributions to the literature of online education. For example, our results showed that teachers applied Live Video Streaming (LVS) on multiple social media platforms and re-purposed different entertainment features to deliver online teaching for better student engagement; some teachers came to enjoy this new form of instruction after being resistant to it in the beginning; and students developed a better sense of intimacy with their teachers after experiencing certain online interactions. Our work also reveals the remaining challenges and prospects of LVS-based online education and sheds light on the future design of collaborative technologies for online education.

CCS Concepts: • **Applied computing** → **Computer-assisted instruction**; *Distance learning*; • **Social and professional topics** → *K-12 education*.

Additional Key Words and Phrases: Online Education, Live Video Streaming, Livestreaming, Education Equality, Transition

1 INTRODUCTION

With the outbreak of COVID-19 worldwide, education systems in many countries are shifting sharply from face-to-face to online teaching. Starting in early February 2020, China's government

Authors' addresses: Xinyue Chen, chenxinyue_flora@pku.edu.cn, Department of Information Management, Peking University, Beijing, China; Si Chen, sic3@illinois.edu, School of Information Sciences, University of Illinois Urbana-Champaign, Champaign, Illinois, USA; Xu Wang, xuwang@andrew.cmu.edu, Human-Computer Interaction Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA; Yun Huang, yunhuang@illinois.edu, School of Information Sciences, University of Illinois Urbana-Champaign, Champaign, Illinois, USA.

required all education systems, including K-12 and colleges and universities, to implement online education [42], which means more than 200 million students and 20 million instructors at all levels must carry out online education activities [108]. The sudden influx of hundreds of millions of users poses new challenges to the existing online education infrastructure. The sharp transition heightens the intensity of existing online education issues (e.g., difficulty promoting student engagement) and further challenges education equality, which is a result of, but is not limited to, the vast disparities in teachers' online experience and technical backgrounds, students' age, families' economic status, and schools' support [20, 41, 64]. From the students' perspectives, not all students have access to the Internet so that some low-income and more heterogeneous school districts are struggling with whether to continue teaching online [64, 67]. From the teachers' perspectives, typical online teaching requires time and effort from teachers to develop online courses. It usually takes hundreds of hours for instructional designers or teachers to develop an online course, including video lectures, online activities and assignments [31, 33, 69, 106]. Therefore, prior research on the best practices of online teaching and learning, assuming there is sufficient time and resources for educators to prepare, may not be easily or quickly applied during this crisis [33].

The adoption of Live Video Streaming (LVS) for online education via mobile devices provides an opportunity to address the time constraints and limited resources. In China, mobile devices are more prevalent compared to personal laptops, which accounts for 817 million of the 824 million Internet users [65]. Livestreaming is an increasingly popular form of mobile-based social interaction that people use on a daily basis [28, 60]. Online users of livestreaming have reached 433 million in China, accounting for more than half of the total Internet population [11]. Prior research has shown that online education through livestreaming has been practiced in China for a period of time [96]. The extensive usage of livestreaming makes it a natural and popular choice for schools and teachers to adopt to broadcast their classes online during this transition [15].

Prior work studied LVS in many contexts, e.g., gaming [29], e-commerce [60], cultural heritage [58], and civic engagement [17]. Using LVS-based platforms for informal learning also began to draw attention, e.g., online tutoring [96], programming [22] and language learning [10]. However, using LVS-based platforms for conducting *formal online education across different levels (from K-12 to college)* is under-explored. This work is situated in a particular context, when both teachers and students experience a sharp transition during a global pandemic and when teachers do not have face-to-face options and do not have enough time or training to prepare online courseware. The social and psychological nature of using LVS for formal education in this context differs from those discussed in prior work when online education was not the only option for teachers and students.

In this work, we conducted in-depth interviews with 15 teachers and 18 students across different education levels in China. We applied a multi-stakeholder approach to uncover conflicts as well as shared and unique concerns between teachers and students when using LVS platforms for online education. **Our work makes the following contributions to the HCI and CSCW communities.** First, we provide comprehensive perspectives of the challenges, practices and prospects of LVS-based online education as a result of many technical and social factors. For example, teachers and students re-purposed the entertaining features of several existing social platforms for formal online education, which subsequently fostered a more intimate teacher-student relationship–disrupting the traditionally hierarchical teacher-student relationship in Chinese culture. Second, we contribute new understandings of how the unique context, when teachers and students have no face-to-face options, impacts the adoption of LVS-based platforms for formal education. For example, some senior K-12 teachers who struggled with online teaching due to their low technical competence and insufficient training for online teaching, changed their attitude and gradually came to enjoy online teaching. Our findings provide practical implications for preparing teachers and students for online or blended education in the future. Third, our work was conducted in China,

the first country to reinforce online education at all education levels during the global pandemic. Our findings, e.g., about both stakeholders' concerns and practices of impression management and insufficient online interaction through multi-platforms, can inform scholars, system designers and practitioners in other countries and areas to address potential issues under the similar situations in a proactive manner.

2 BACKGROUND AND RELATED WORK

In this section, we first provide background information for this study. Our study takes a technology adoption perspective where we investigate how teachers and students behave and adapt during the transition to online education. The development of online education has come a long way, from early asynchronous e-learning through email or discussion boards[94], to synchronous e-learning through videoconferencing tools [7, 37, 38], to the recent research on developing online courseware, e.g., MOOCs [49, 105, 106], and online peer learning systems [54, 55]. In this section, we present research developments on online education that are the most relevant to our research, including synchronous online teaching, Live Video Streaming-based teaching, and the adoption of educational technologies. We then propose our research questions given the related literature.

2.1 Context of the Research

This study was conducted in China. Since February 5th, following the official guidelines, teachers at all levels applied various types of online education platforms [21] to conduct online teaching, including social media, videoconferencing, professional teaching platforms, etc., among which QQ, DingTalk, Tencent Class, and other applications were widely used [15]. For example, according to statistics from Tencent Class APP, five million K-12 teachers and students flocked to their online learning platform within an hour that morning [14].

The sharp transition is particularly challenging for teachers and students who did not have a lot of online experience or a technical background, who did not receive platform support from schools, and whose families were not in good conditions economically. The top-ranked universities made adequate preparations, because they were able to afford online education companies and had customized systems for their teachers and students in a short time, e.g., Peking University's ClassIn [80], and Tsinghua university's Rain Class [89]. Their teachers and students carried out online training activities, and were arranged for professional technicians to solve the difficulties of teachers and students in the use of the platforms. With relatively high ICT literacy, college teachers and students in these schools managed to use professional teaching platforms for online teaching.

However, most other public schools, especially K-12, did not have dedicated platforms and devices or online teaching and learning experience. Many schools could not afford the complex operation of the professional platforms, such as ClassIn and Rain Class, in such a short time [11], so their students and teachers had to find their own ways to deal with challenges in such an urgent transition. Because live video streaming apps, such as DingTalk and QQ, have been widely adopted by Chinese online users, many K-12 teachers and students chose to conduct online education through live video streaming, even though they frequented those apps mainly for entertainment purposes in the past [11, 41].

2.2 Synchronous Online Teaching Opportunities during Transition

Asynchronous and synchronous online teaching are two basic forms of online instruction. Prior research has discussed the relative benefits of asynchronous and synchronous online teaching. On the one hand, synchronous online teaching is easier to implement and better simulates traditional class teaching and is more familiar to teachers [74], e.g., lecturing to students with the use of a

whiteboard or other visual aids, students raising their hands to ask questions, speaking one at a time, etc. On the other hand, asynchronous environments had more positive effects than synchronous ones in terms of student achievement. Research suggests that asynchronous e-learning better supports cognitive participation, such as increased reflection, whereas synchronous better supports increased motivation [7, 38].

For example, MOOCs are the most widely recognized form of asynchronous online teaching. In MOOCs, lecture videos are pre-recorded. Many studies find that recording videos places a heavy workload on teachers and requires extra support from schools and technicians [106]. Faculty members reported spending hundreds of hours to develop materials for a MOOC, and some admitted that the preparation itself was "a full-time job" [49]. Such methods would not be applicable in settings where resources were limited and teachers were not trained to develop their own online courses, especially in developing countries. Although advocates for MOOCs have heralded them as vehicles for democratizing education and bridging divides within and across countries, studies have shown that MOOCs do not spread benefits equitably across global regions judged by completion rates, and MOOCs prevailed educational disparities for reasons such as less broadband Internet access, cognitive burden, and less capability in less-developed countries [46, 47].

Other drawbacks of asynchronous online teaching have been discussed, mostly in higher education contexts. Some scholars have highlighted the impact of technical problems in online teaching, such as the lack of technical support and the crisis of time management [107]. Others have discussed the interaction and attendance in an online class; for example, students may feel a decreasing sense of social presence [70], and may experience social isolation and impoverished social interactions with their remote peers[87]. Teachers experienced mood swings when transitioning to online classes due to the lack of interaction in class and low attendance of students in online class [106]. Studies have found that the retention rate for asynchronous online courses has been low, especially when there is a lack of social companions [63, 105] and a lack of timely communication between teachers and students [16]. In addition, some studies paid attention to the effect of showing faces and body language during an online course; the findings show that adding the instructor's face to lecture slides can encourage learners' positive affective responses [45].

Compared to asynchronous online teaching, synchronous online teaching can increase student's social presence by real-time communication [66], enhances connection between teachers and students and students community by live session [86], has a positive impact on inspiring natural discussion for both teachers and students in class [81], and has been found to increase student motivation [7, 38]. These are all critical outcomes to consider and emphasize during times of uncertainty [83] and could benefit the most vulnerable learner populations [78].

2.3 Live Video Streaming (LVS) for Synchronous Online Education

Prior work on Live Video Streaming (LVS)-based online teaching has studied two types of platforms: videoconferencing and livestreaming platforms. Videoconferencing is defined as synchronous video and audio communication across geographic sites [53]; livestreaming is defined as an emerging practice of broadcasting video of oneself in real-time to an online audience [22]. Videoconferencing platforms (e.g., Zoom and Skype [52, 76, 88]) have been discussed in the context of formal learning; and livestreaming platforms (e.g.,Twitch.tv [22, 27]) are more explored in the context of informal learning. Both platforms imitate real classroom environments, where teachers can give video lectures in real-time and students can watch the lectures via video streaming [30]. Teachers and students can also interact via text message as needed, such that timely feedback can be given to student discussions [1]. The major difference between the two platforms lies in the relationship between the streamer and the participants. When using videoconferencing platforms, the teacher and the students equally participate in the meeting when everybody has the option to

turn on his/her video camera. This interaction mode is more suitable for small to medium sized classes [57]. Livestreaming, however, is more streamer-centered and could benefit larger classes since only the streamer's camera is on. Though the boundary can be fuzzy at times, e.g., if the host of a video conference disables participants' video cameras, it resembles the form of livestreaming.

Prior research on videoconferencing found that it can be used to improve intercultural understandings, digital literacy, and collaborative techniques [53]. Pisutova [73] discussed effective ways to engage students in videoconferencing, e.g., generating excitement for the tools, pilot them on a small scale, and be prepared for trial and error. Gillies [25] found that students felt most engaged during videoconferencing sessions when they actively participated in the session and when the topic was important and practical. However, videoconferencing platforms for online teaching are mostly applied in higher education since they have higher technology requirement for both teachers and students [5, 57]. Often times, desktop computers are required to realize the benefits of videoconferencing [25].

Livestreaming is defined as broadcasting video of oneself in real-time to an online audience [22]. Websites that provide this function include Twitch.tv, which primarily provides streams of video game-related content, and other platforms such as Youtube, Tiktok, and Kuaishou. Livestreaming encourages real-time interaction compared to non-live videos [58]. Users' intention and behaviors in using a livestreaming platform have been discussed in many fields and platforms, e.g., games and sports [32, 71], intangible cultural heritage [58], and civic engagement [17]. However, there has been little research on the use of livestreaming platforms for formal education. Prior work showed benefits of using livestreaming to support informal learning, such as introducing people to computer programming through broadcasting programming competitions on Twitch [27], and connecting streamers with audiences to support the growth of online programming communities [22]. Others have demonstrated the benefits of re-purposing livestreaming platforms to support online tutoring [96] and language learning [39]. It was also found that the combination of live teaching through livestreaming platforms and social communication through chat software can greatly improve the intimacy between teachers and students [39]. Other works have studied using livestreaming for knowledge sharing. For example, StreamWiki is a tool to produce archives to support post-hoc learning following livestreaming sessions [59].

In this work, these existing platforms offer a vehicle for us to study LVS-based platforms for formal learning. Our findings apply to synchronous online teaching and can be carried out through these platforms.

2.4 Educational Technology in Real Contexts

There is a large body of work proposing and studying novel educational technologies in K12 and college classrooms. Recent work by Holstein et al. [34, 36] explored the design of teaching augmentation tools to combine human and AI instruction in K12 classrooms. In college classrooms, Wang et al. [92] developed an authoring tool to support instructors create effective practice questions. Other work has explored ways to engage students and enhance concentration in class [3, 90]. In MOOC settings, Kulkarni et al. developed peer review systems to scale feedback and learning. These prior work demonstrate ways to enhance in-person, online and blended learning. However, these technologies are mostly designed for regular in-person or online classrooms. Facing this sharp transition, teachers and students are required to switch to online teaching and learning without preparation, so that new user needs and challenges emerge. Understanding the challenges teachers and students encountered during the transition could help design educational technologies that better address user needs and have bigger adoption potential.

Educational technology adoption is also culture bounded. Prior research has shown failure when deploying well-designed educational systems in a different cultural context. For example, intelligent tutoring systems have shown great success in the US [48]. However, when deployed in a context where kids collaboratively solve math problems instead of working on their own computers, the system does not work as expected [68]. Much prior work has demonstrated the importance of cultural factors when designing novel educational technologies, e.g., a virtual tutor that speaks dialects when teaching science subjects [23] and a mobile literacy technology for low-literate families [61]. Our work provides another example of understanding cultural and contextual factors to inform educational technology design. We consider unique cultural and contextual factors in our work. For example, the explicit hierarchical structure between teachers and students in China [104] makes students more reluctant to participate in classroom discussions compared to western cultures [91]. The sharp transition to online teaching during a global pandemic introduced new challenges for both teachers and students to carry out regular educational activities. These cultural and contextual factors make adapting existing practices challenging. Our work provides insights on how to design LVS-based online education that address the needs and challenges faced by stakeholders in these contexts.

As a summary of the above literature, prior work shows the benefits of synchronous online teaching to maintain student attendance and increase student motivation, however, there is a lack of understanding on teachers' and students' experience of using live video streaming to conduct online teaching and learning. Prior work on online education has focused on novel technologies and best practices to provide resources and support for teachers to prepare for online teaching. The assumption of sufficient resources and support does not apply during this sharp transition. In this study, we aim to understand how and why teachers organically selected LVS-based online teaching and how students and teachers adapted through the transition.

Given the above literature and background, we propose the following three research questions:

RQ1: What are the challenges teachers and students face when transitioning from offline to online education using live video streaming?

RQ2: How do teachers and students address the challenges involved in this transition?

RQ3: What are the prospects of using live video streaming for online education?

3 METHOD

3.1 Recruitment and Data Collection

We recruited interviewees by posting recruitment scripts in WeChat groups made up of teachers from various levels, institutions, and areas. We also sent private messages to teachers and students who complained about the experience of live videostreaming courses in Sina Weibo, and Zhihu. There were two criteria for our participants: (1) they are learning or teaching only online because of the stay-at-home order, and (2) they have tried live video streaming for teaching and learning in this context. Eighteen volunteers signed up for our interview (8 teachers and 10 students). Through snowball sampling, we further contacted 15 interviewees (7 teachers and 8 students). Finally, we reached a total of 33 qualified participants, including 15 teachers and 18 students.

We conducted semi-structured interviews with them individually via telephone. The duration of each interview ranged from 30 minutes to 90 minutes, with an average of 35.2 minutes for students and 46.8 minutes for teachers. All interviews were recorded, noted, and transcribed. The information of specific interviewees is shown in Fig.1 and Fig.2. Before the interviews, all participants consented the conversation could be recorded. Before starting the interview, we asked the participants for necessary information (age, area, school level, prior experience in online teaching and learning, etc.). Then we asked participants about whether they faced any challenges and if so,

how they addressed the challenges in such a short period. We asked about the challenges faced by teachers and students at different time periods, e.g, before, during, and after live video streaming classes, and across different types of live video streaming platforms. Also, we are concerned about the overall prospect brought by the transition from offline to online live video streaming.

ID	Cities	Ages	Years for teaching	Sex	Stage	Used online teaching or not	Subject	Main platforms
T1	Tier2	51~60	30-35	M	Junior high school	N	Math	DingTalk
T2	Tier2	41~50	25-30	F	Junior high school	N	History	QQ
T3	Tier2	41~50	20-25	F	Junior high school	N	Chinese	QQ
T4	Tier2	31~40	15-20	F	Junior high school	N	Chinese	QQ
T5	Tier2	41~50	20-25	F	Junior high school	Y	Art	QQ
T6	Tier2	41~50	20-25	M	Junior high school	N	Math	QQ
T7	Tier2	41~50	20-25	F	Junior high school	N	Chinese	Tencent Class
T8	Tier2	31~40	10-15	M	College	Y	Mechanical design	Chao Xing learning platform
T9	Tier1	41~50	20-25	F	College	Y	Manufacturing technology	DingTalk
T10	Tier2	41~50	15-20	F	College	Y	Physics	enterprise WeChat
T11	Tier2	41~50	25-30	M	College	N	CPA	QQ, Rain class
T12	Tier2	31~40	15-20	F	High school	N	Math	Tencent Conference
T13	Tier3	18~25	0-5	F	High school	Y	Chinese	Bilibili
T14	Tier2	41-50	25-30	F	College	N	Principles of management	QQ
T15	Tier2	51-60	25-30	F	College	Y	Product innovation design	ZOOM

Fig. 1. Summary of teacher participants.

3.2 Data Analysis

We used a grounded approach [9, 85] and conduced a thematic analysis [8] on the interview data, in a similar way as done in [18, 19]. NVIVO software was used to support the coding process. First, two authors familiarized themselves with the data by reading the transcripts and memos carefully. Two authors then did open coding with four participants' transcripts (two students and two teachers) independently and then met to discuss and compare their codes. After that, the first author coded the remaining data through an iterative process, in which she met with the second author regularly to discuss the codes and iterate on the findings. The emerging codes included "copyright concerns," "uncertainty of the technology," "impression management," "usage of red envelope to increase in-class engagement," and "connect more intimately with students in and after class," etc. In the second round, all authors discussed the codes, and worked together to collapse codes through the axial coding process into the 6 major themes we are presenting in this paper, including: shared challenges between teachers and students; conflict challenges between teachers and students; unique challenges for teachers; unique challenges for students; students' and teachers' practices of addressing the challenges; and the prospects of LVS-based online education.

4 FINDINGS

Before answering the research questions, we provide an overview of what technological platforms our participants used for online education during this transition. Figure 3 presents the main platforms used by teachers and students for online teaching and learning in our interview. We clarify the features and functions of these platforms and their respective in-class usage scenarios. In the

id	cities	ages	sex	stage	main platforms
S1	Tier1	21	F	College	Bilibili,QQ,Tencent class,Chao Xing learning platform
S2	Tier1	20	F	College	ClassIn, DingTalk
S3	Tier2	21	M	College	QQ, Tencent Conference, Tencent class
S4	Tier1	21	M	College	Tencent Conference, DingTalk, ZOOM, Rain Class
S5	Tier3	21	F	College	QQ,Tencent class
S6	Tier2	14	F	Junior high school	QQ, DingTalk
S7	Tier1	22	F	College	Rain class, DingTalk, Tik Tok, Tencent Conference
S8	Tier2	17	F	High school	Tencent Conference, QQ
S9	Tier1	20	F	College	ZOOM
S10	Tier1	21	M	College	ClassIn, ZOOM, Tencent Conference, DingTalk
S11	Tier2	15	F	Junior high school	QQ,DingTalk
S12	Tier1	21	M	college	ClassIn, Tencent Conference
S13	Tier1	23	M	college	Tencent Conference, DingTalk
S14	Tier2	18	F	High school	Tencent Conference, QQ
S15	Tier2	17	F	High school	Tencent Conference, QQ
S16	Tier1	13	M	Junior high school	DingTalk, WeChat
S17	Tier1	13	F	Junior high school	DingTalk, WeChat
S18	Tier2	14	F	Junior high school	QQ, DingTalk

Fig. 2. Summary of student participants

column "Entertaining Features", we only included entertaining functions used for assisting live video streaming classes but not for other uses. The column "device access" means the device teachers and students can use to have LVS-based classes through the platform. The column "structure" presents the teacher/student relationship in the platform. We only present the features and functions mentioned in our interviews, which represent a sample of teacher and student users in China. Below, we briefly review the systems in three categories.

First, livestreaming functions are provided by social media platforms such as QQ and WeChat. They also offer functions for teachers and students to communicate in and after class. In line with Chinese users' habits, these group-chat-based platforms have become the most popular social platforms in China for many years. Before the outbreak of COVID-19, these platforms were already a regular way for teachers to communicate with parents and students daily. The livestreaming video platforms with a higher emphasis on entertainment, such as Tik Tok and Bilibili, which were designed for games, singing, makeup, and shopping, can also be used to deliver livestreaming courses open to the public and can be viewed by a large out-of-class audience. In these platforms, the relationship between teachers and students is hierarchical (or streamer-centered), which means that only teachers are showed on the screen, and students can communicate with the teachers through texting or sending audio messages. Due to the social nature of the social media platform itself, they have rich entertainment and interaction functions in livestreaming, such as emojis, dammaku, and gifts or reward giving, which can help to make the livestreaming course more entertaining to engage students. These platforms can also support the mobile terminal very well, which adapts to the situation that the mobile terminal is more popular than the PC terminal in China.

Categories	Typical Platforms	Entertaining Features	Device access	Structure	Participants
Social Media	QQ	Emojis Memes Virtual gift giving Red envelopes	PC & mobile	Hierarchical & Flat	T2,T3,T4,T5,T6,T11,T1, S1,S3,S5,S6,S8,S11,S1, S15,S18
	WeChat	Emojis & Memes Red envelopes	PC & mobile	Hierarchical	S16,S17
	Bilibili	Emojis Memes Virtual gift giving Danmaku	PC & mobile	Hierarchical	T13,S1
	Tik Tok	Emojis Virtual gift giving Danmaku	Mobile only for students	Hierarchical	S7
Enterprise Collaboration Platform	DingTalk	Red envelopes Emojis & memes	PC & mobile	Hierarchical & Flat	T1,T9, S2,S4,S7,S10,S13,S16,S17
	Zoom	None	PC & mobile	Flat	T15, S4,S9,S10
	Tencent Conference	None	PC & mobile	Flat	T12, S3,S4,S7,S10,S12,S1,S14,S15
	Enterprise WeChat	Emojis	PC & mobile	Flat	T10
Professional Teaching Environment	ClassIn	Emojis	PC only for teachers	Hierarchical	S2,S10,S12
	Rain Classroom	Red envelopes	PC only for teacher	Hierarchical	T11 S4,S7
	Tencent Class	Emojis	PC only for teacher	Hierarchical	T7 S3,S5
	Chaoxing Learning	None	PC & mobile	Hierarchical	T8 S1

Fig. 3. Platforms used for Live Video Streaming

Second, videoconferencing features are provided by enterprise collaboration systems such as DingTalk, ZOOM, and Tencent Conference are widely used by teachers for synchronized courses. DingTalk, a platform used for team collaboration in work, can integrate the functions of livestreaming, videoconferencing, group chat, and doc uploading and editing, to meet both in-class and after class interaction needs for teachers and students. But videoconferencing platforms such as ZOOM or Tencent Conference can only be used for live class and in-class activity. These platforms have a flat structure, with both teachers and students able to open videos, have their avatars of the same size, and speak through the microphone.

Third, professional teaching platforms provide structured class and material management functions, and provide rich teaching functions in the LVS-based course, such as real-time statistics of students' listening data and answer data, group discussions, in-class tests, and so on. However, these platforms have requirements for teachers' digital literacy and equipment to some extent. Some platforms can only open live courses on the PC, while others can only use partial functions on the mobile phone. The structure in this kind of platforms is almost hierarchical, because they are teacher-centered and the teacher has the power to close the video or audio of the students.
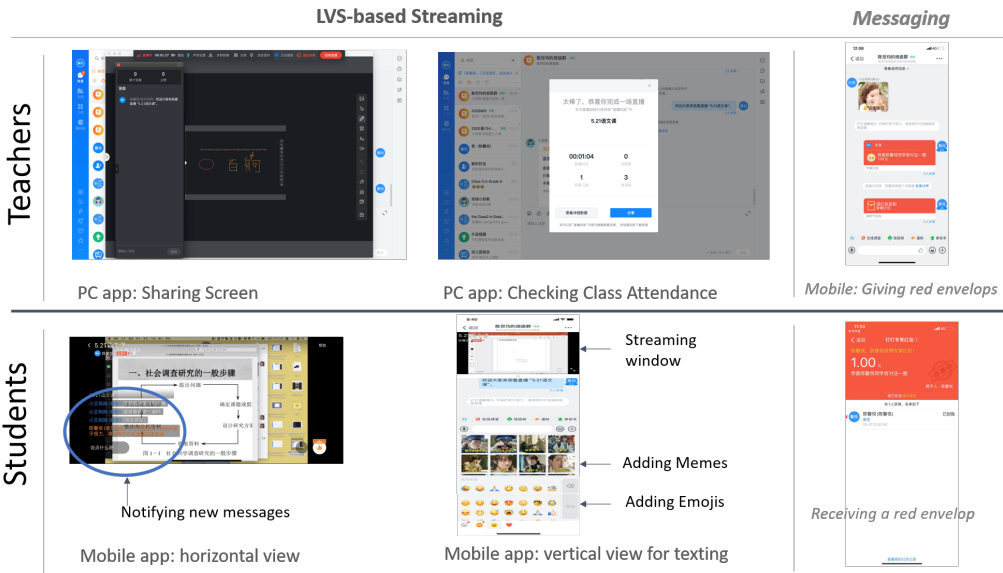
Fig. 4. A typical workflow of using live video streaming in DingTalk (similar with QQ) for online courses. a) Teachers will use the platform's laptop app to deliver online lectures and check students' class attendance. b) Teachers can also use the mobile app for more interactive activities while using the PC for LVS class, such as sending red envelopes. (Red Envelope, a monetary gift given in Chinese traditional culture, symbolizes good luck, and now can be used in social media, e.g., DingTalk, QQ, WeChat.) c) Students can use the mobile app for class; it has a horizontal and vertical view. In horizontal view, students can watch the video more attentively, and in the vertical view, students can use more interactive features like sending memes or emojis, and receiving red envelopes.

Fig.4 illustrates a sample workflow of how teachers and students have livestreaming classes and interact with each other in DingTalk. More specifically, the teacher can open the live studio through both the computer and the mobile phone. After opening the live studio, teachers can freely switch between screen sharing and blackboard annotation mode. Additionally, the system provides real-time classroom statistics, including data such as check-in number, attendance, time of watching, and the number of comments. In class, in complement to streaming, teachers can interact with students by sending out red envelopes, emojis, and memes in the text-based chatroom. Additionally, teachers can use chat rooms to assign quizzes and assignments directly and view system notifications such as 'Please avoid impolite language.'

While watching streaming classes, students can communicate and open docs and assignments in the text-based chatroom. They can make comments, send emojis and memes, accept red envelope and click "likes". These memes are dynamic, which are a popular way for Chinese students to communicate online. These interactions, along with recordings, are saved on the cloud system and can be easily retrieved after class. They also can use screen mirror techniques to watch it on bigger screens, like televisions. In livestreaming class, the system will also provide notifications, including to use polite language, and protect your eyes from the screen.

Although previous research studied videoconferencing and livestreaming separately, in real practice, our participants (both teachers and students) considered them to have the same learning mechanism, due to the nature of real-time video streaming and text communication functions.

Thus, in this paper, we use "Live Video Streaming (LVS)" to refer both platforms. The above provides an overview of the LVS-based platforms and demonstrates a sample workflow of using LVS-based platforms for online education. In the remainder of this section, we will address our proposed three research questions.

4.1 Challenges Faced by Teachers and Students (RQ1)

From the perspective of two stakeholders, we present the shared, conflicting, and unique challenges that the transition from offline to online live video streaming brings to teachers and students. Shared challenges are challenges that both teachers and students were concerned about and had a similar impact on their LVS-based class experience. Conflicting challenges refer to the issues mentioned by both teachers and students, but with different perspectives and attitudes, e.g., one is positive and the other is negative. Unique challenges are unique problems for one party. Trust, privacy and consequences of leaving more digital footprints, missing eye contact and body language, and impression management are shared problems both teachers and students face. Teachers and students have conflicting views on switching between multi-platforms, different expectations for students' engagement and the balance between entertainment and teaching. Panic from real-time mistakes, senior teachers' learning curves and mood swings are unique challenges for teachers; lack of peer presence is a unique challenge for students.

4.1.1 Shared Challenges. In this section, we focus on the shared challenges both teachers and students face, which were mentioned by both stakeholders as important issues affecting the user experience of live video streaming courses. These problems include the trust, privacy and consequences of leaving more digital footprints, missing eye contact and body language, and impression management.

Trust, Privacy and Consequences of Leaving More Digital Footprints. When transitioning to only online teaching through live video streaming, most teachers (80%) and students (66.7%) have experienced a crisis of trust.

First, teachers and students didn't trust each other. From the teachers' perspective, students might have some inappropriate behaviors such as uploading videos of lectures or making memes with screenshots and posting them on the Internet, which infringe on the right of the teacher's image, as T1 (Male, Junior high school, DingTalk) said, *"I was afraid of opening the camera because students may upload my photo or video into the internet, which means I was exposed to the public."* They were also concerned about their course materials being uploaded by students to the Internet; this was mentioned by ten teachers (66.7%), which brought significant challenges for them to protect their intellectual property rights. Teachers did not want their work to be freely shared, copied, and revised without permission, but it frequently occurred during online livestreaming courses. T12 (Female, High school, Tencent Conference) gives her example, *"My colleague's courseware were passed to other schools by one of the students. He was angry because he had worked all night to prepare the materials. But it is now being used at random by other teachers, who even contact him and ask if they have any new information. It's disgusting."* From the students' perspective, they also were afraid that classmates were making memes out of screenshots and they were being teased for it. Apart from this, they were worried that teachers would supervise them through the camera, as S16 (Male, Junior high school, DingTalk) mentioned, *"I heard about that teachers can monitor what students' do in the phone by the data recorded by DingTalk, and they also can watch what students do in home by the camera. It's very scary!"* Although the veracity of these claims needs to be further verified, it reflects students' fears and concerns about these issues.

Second, both teachers and students didn't trust the live video streaming platforms. User data protection measures were weak in some platforms, which may lead to the disclosure of users' personal information. Three (16.7%) students mentioned this kind of experience. S1 (Female, College, Bilibili, and QQ and Tencent Class) faced this kind of situation, *"I have received a text message before, which told me I didn't check-in one class and asked me to send my students id, name and phone number. After I looked up the message online, I found it was a scam message. And if I reply to this message, more personal information will be stolen."* In addition, the office platform, such as DingTalk, enterprise WeChat, etc., required and presents users' personal information, such as phone number and home address, which can be seen by all users in the class group. Because the platforms are originally designed for collaboration within the company, their access to this personal information can help improve productivity, but when used for teaching on a large scale, user privacy may need to be reconsidered.

Third, what concerned students and teachers the most was the potential audience in cyberspace. Due to the open entrance of some platforms, such as TikTok and Bilibili, live courses could be seen by all users, and conference links on ZOOM and other platforms could be freely shared, which means students who are not registered with the school can quickly enter a streaming session to listen to the course. T14 (Female, College, QQ) explained this, *"Because of the public features, my words and actions are not only seen by students, but also are under parents' supervision, and even by other users of the platform. So I have to deliberately restrain my expressions and movements from avoiding harmful effects that make me feel less free and natural in livestreaming."* S1 (Fale, College, Bilibili) mentioned a typical example about this, *"Once a classmate forgot to close his microphone in class and he was talking about his career plan. It is very unlucky for him that the livestreaming class was in Bilibili and open for public, and almost about a thousand audience heard it."* Once the livestreaming videos were uploaded into the Internet, it might be taken out of context and that some of the ideas mentioned in the course may be maliciously interpreted and generate a negative public opinion. This challenge is especially severe for teachers in humanities and social sciences. As T10 (Male, College, Enterprise WeChat) said, *"I'm afraid to express myself during livestreaming. If the audience uploads the video and someone maliciously interprets something, it will impact my work and life. Because livestreaming is in real-time, there is no chance for me to change my expressions."* Such concerns may be related to the monitor of online discourse space in China, where teachers may be punished for inappropriate expressions.

Missing Eye Contact and Body Language The real-time feedback in online livestreaming courses is undoubtedly better than that of recorded classes in the past, but it still fails to meet teachers' and students' needs, which has become the biggest challenge from both perspectives. Almost all teachers (93.3%) believed that online teaching's real-time interaction was reduced , and they had difficulty in perceiving students' status and getting timely feedback. As T1 (Male, Junior high school, DingTalk) said, *"The biggest gap between online and offline teaching is that I cannot get timely feedback from students. Without timely feedback from students, it is difficult for me to control the pace of the class."* Similarly, students also expressed the difficulty of real-time communication in class (66.7%). Most students thought that giving feedback to teachers in live video streaming classes would take more time, thus affecting the efficiency of course.

The most important reason for lack of real-time feedback is the lack of body language. On most livestreaming platforms, the teacher can turn on the camera, and the students can see the teachers' timely expression and body language, providing more real-time information than the traditional recorded MOOC. But in fact, the teacher's video window occupied only a corner of the screen, making it difficult for students to observe the teacher's expression and action. At the same time, since most of the students did not or were not allowed to turn on the camera, eye contact between teachers and students was remarkably reduced. In a livestreaming platform, the streamer didn't

care much about what the viewer was doing, but in a formal teaching environment, teachers and students need to perceive each other, making the lack of body language and eye contact a serious concern in the LVS-based class.

For both teachers and students, eye contact and body language are related to enthusiasm in class. For some teachers, sitting in front of the computer at home, without the sense of ceremony of standing on the rostrum in the classroom, makes it difficult for them to generate passion and motivation in teaching. Like T8 (Male, College, Chao Xing Learning Platform) expressed, *"I was sitting and relaxed, so I didn't feel like I was teaching and I can't have rich body language like the class offline so I feel no passion for the class so that the body language is not so rich."* For students, their perceived teaching presence decreased, which affects their cognitive presence. As S11 (Female, Junior high school, QQ, and DingTalk) explained, *"What I hate most about livestreaming is that I can't feel eye contact with my teacher. When I was offline, the teacher would always encourage me with amiable eyes. But now we can't see each other, making me easily distracted during class."*

Impression Management. Impression management is another important challenge faced by teachers and students in a LVS-based class, mentioned by 7 teachers (46.7%) and 12 (66.7%) students. Because they need to open their camera in class, which means they can see themselves, this may bring burden to impression management and make them more aware of the self image in class. Some teachers and students mentioned paying attention to the camera's angle and whether to turn on the beauty effect when opening the camera, like S18 (Female, Junior high school, QQ) said, *"I can perceive and care more about not looking pretty when the teacher asks us to turn on the camera in the live class. I thought about turning on the beauty effect of the camera, but I was afraid my classmates would laugh at me."* In addition to personal impression management, the management of family impression is also concerned by teachers and students and unique to this context because they need to show their family environment into the class. They tidy up their rooms before the live sessions and choose a particular background suitable for turning on the camera, such as a clean wall or a tidy study. It's a struggle for teachers and students from low-income families to show their home, like T5 (Female, Junior high school, QQ) said, *"My house is very old and poor. I feel very embarrassed to let my classmates see the inside of my home, so I usually have classes on the balcony even in the playground."*

4.1.2 Conflicting Challenges between Teachers and Students. Some other challenges were mentioned in the interviews by both teachers and students, but they held different views on these challenges. These challenges include switching between multiple platforms, conflicting expectation on students' engagement, and different attitudes toward entertaining and teaching.

Switching Between Multi-Platforms. During the sharp transition, there was no set platform for teachers and students to use, so they needed to choose and compare among many platforms that can stream live video. However, it was not enough to just provide the live video streaming feature when teachers chose one platform as a teaching tool. After-class communication and class management (e.g., collecting assignments) were also needed. Barely any platforms did great in all three aspects. Therefore, teachers and students often needed to choose between various kind of platforms and identify their workflow by combining multiple platforms. In our interview, eight (53.5%) teachers and twelve (66.7%) students mentioned this challenge, however, they held different views about this.

In order to achieve a better teaching effect, some teachers chose to use one platform for live video streaming and another for communication. For example, T12 (Female, High school, Tencent Conference) said, *"I use Tencent conference for teaching because it can support the in-class interaction best, and I use WeChat for Q&A or communicating with students and parents after class, which can provide real-time communication features. Combining the two platforms, I can achieve a best teaching*

experience online." But switching between platforms was a huge inconvenience and overload for students. Unlike teachers, students need to take classes in not only one subject but many, so they need to adapt to multiple platforms chosen by teachers in different subjects. By comparing fig.1 and fig.2, we can see that students use many more platforms than teachers. As S14 (Female, High School, Tencent conference and QQ) said, *"we use Tencent Conference for classes, but it can only be used for an in-class activity. The communication before and after classes need to be conducted in QQ and WeChat. Every teacher set up a group chat in QQ or WeChat to help connect after class so that we have to switch back and forth between different platforms and at least ten chat groups, causing us to miss a lot of important messages."*

In addition, students not only used muti-platforms for having class and communicating with teachers. They also needed to complete assignments, work on group projects, and take exams. These heavy tasks are even more exhausting for students under the influence of switching between multi-platforms. As S10 (Male, College, ClassIn) said, *"Completing group work online is also a big challenge. We need to talk through live video streaming, but at the same time we need to collaborate on the collaboration platforms. After the synchronous discussion, we also need to conduct asynchronous communication, file transfer, modification and so on in social platforms such as WeChat. Switching from platform to platform, going to a lot of meetings, replying to a lot of messages, these all overwhelmed me."* In the interview, S15 (Female, High School, QQ) talked about the online exam experience as a K-12 student, *"We need to open two platforms for the test. We used Tencent Meeting as a channel for real-time communication with our teachers, who asked us to open videos to monitor us. At the same time, we also need to log into a professional exam platform to answer the questions. Such a test makes me easily distracted and affects my score. And many students take advantage of the lack of supervision in online exams to cheat, which makes me very angry."*

Conflicting Expectations on Student Engagement. In the live video streaming course, most teachers (73.3%) clearly felt the decrease of student engagement. They were anxious about this and wanted to increase student engagement in a variety of ways. In terms of the phenomenon of the decrease in engagement, the most obvious was that the number of students participating in the interaction is significantly reduced. T6 and T8 said that few students responded to the class activity. Particularly typical was the experience of T12 (Female, High school, Tencent Conference), *"When I ask a question, some students will deliberately not answer. They pretended the Internet broken down and didn't turn on the microphone."* Due to the limitations of live courses, teachers and students have a long physical distance between them; it is difficult for teachers to teach and supervise students as they do offline. Many teachers (53.3%) reflected the decline in students' initiative to complete the homework, and the number of students submitting the homework showed a downward trend each time. Therefore, teachers took many measures, such as enriching the types of class activities, frequently asking questions, or assigning more homework to engage students. But such actions often backfired. From the students' point of view, although twelve students (66.7%) said that interaction increased during the live lecture, most of them thought such interaction was inefficient. As S10 (Male, College, ClassIn, and Tencent Conference) said, *"Many teachers may not feel that we are focusing on the class, so they frantically increase the classroom interaction, often looking for students to answer questions. Then the time just passed, and we can't learn anything in this way. I don't like the inefficient avtivity and interaction, and it's boring and useless."*

Some teachers increased students' social presence by asking students to turn on their cameras. They though it would help the interaction and real-time feedback to adjust the pace of the class better and increase the sense of reality. As for the students, they are forced to turn it on, so most of them feel deep resentment. Therefore, the students felt that the teacher's request is inefficient and just a formalistic means. They didn't think that turning on the camera would improve interaction. Like S8 (Female, Junior high school, Tencent Conference) said, *"The teacher would ask each of us to*

turn on the camera during the reading class. I thought that was ridiculous. He was just trying to make sure we read our books. But turning on the camera doesn't mean I'm paying attention, so I think this requirement is superficial and has no real effect."

Entertaining vs. Teaching. As social platforms and live video platforms for entertainment are widely used in this practice of large-scale online teaching, the role of entertainment functions in these platforms in teaching has attracted the attention of both teachers and students. These functions include gift-giving, emojis, memes, red envelopes (in East Asian and Southeast Asian societies, a red envelope or a red packet – Mandarin: hóngbāo – is a monetary gift which is given as a reward which symbolizes good luck and is a symbol to ward off evil spirits), and Danmaku.

On the one hand, most teachers (55.5%) were cautious about using entertainment functions in class. They believe the course itself is sacred, and the entertainment function could affect the concentration and absorption of knowledge. As T1 (Male, Junior high school, DingTalk) said, *"I think the class is serious. I don't make jokes in class or use the entertainment functions. This may lead to students not paying attention to the content of the class itself."* Comparatively, other teachers try to use social platforms' entertainment function to arouse the class atmosphere. Such attempts work well at first, but they later began to worry about students' lack of concentration in course content. They considered it conflicting and challenging to balance between the class quality and the use of entertaining functions to attract students. For example, T4 (Female, Junior high school, QQ) expressed her concerns, *"When students send me flowers and gifts, I was worried about whether they were only paying attention to the entertainment functions but not to the class."*

On the other hand, most students (72.2%) think functions such as Danmaku, giving and accepting red envelopes , and giving gifts can make classes more interesting, interactive and create a sense of engagement. But few of the students mentioned that a teacher used these recreational functions proficiently to motivate them. As S7 (Female, College, Rain Class, and Tiktok) said, *"I really like to give gifts to teachers in the class, because I think it is a way for me to express my appreciation to them and show my presence in class. But all the teachers never responded to my actions."* Teachers' overlooking students' use of entertainment features may discourage students from using these interactive features to provide real-time feedback in class, which makes the lack of in-time feedback even more severe.

4.1.3 Unique Challenges for Teachers. In addition to the shared and conflicting challenges, teachers and students individually face many unique challenges, which include all aspects of society, teaching, and technology. For teachers, unique challenges include a longer learning curve for senior teachers, copyright concerns, lack of familiarity with technology, etc.

Panic from Real-time Mistakes. Three reasons led to this problem: 1) unfamiliarity with the technologies, 2) the unpredictable performance of , and 3) the recovery cost of large classes. Almost all teachers expressed their nervousness and worry about class, and 14 of them (93.3%) expressed panic related to real-time mistakes in class, which became the most common challenge for teachers in the transition from offline to online .

In this special context mentioned above, it was the first time for most teachers to try the stream on livestreaming platforms. Many of them were not familiar with electronic devices and also not familiar with the operation of livestreaming. This factor aggravated their fear of using live video streaming. As T2 (Female, Junior high school, QQ) said, *"There was a lot of pressure at the beginning because I didn't know how to use it and how to operate it. I have always had a fear of using the computer, and the more afraid the more likely it is to go wrong."*

Unlike the traditional MOOCs' asynchronous teaching mode, live video streaming is highly un-editable, making teachers feel uncertain. The teacher had no chance to adjust the speaking or operation errors through repeated recording in the real-time live course, which put a cumbersome

task on the teachers' pre-class preparation and made them more afraid of livestreaming class. Besides, livestreaming is more prone to accidents than recorded video, such as not being able to enter the studio, or suddenly not being able to make a sound, or the connection between teachers and students is broken. The problem of network jam or platform crash is particularly prominent in this livestreaming based online learning practice. In the past, the recorded video-based online course gave students the freedom to learn on the platform at any time. Still, a livestreaming course required students to enter the live studio on time so that a large number of users will rush into the platform at the same time, thus exacerbating the problem. As T7 (Female, Junior high school, Tencent Class) expressed, *"I don't know what will happen in the livestreaming because some problems may appear unexpectedly. So I am more careful and make full preparations."*

The recovery cost also makes the teacher more afraid of making mistakes. The larger the class, the higher the cost of making up for errors. For instance, if the teacher made mistakes such as clicking the wrong button on the platform and closing the live studio by accident in a large-scale class, it would cost more time to re-open the class, or it was difficult to change the platform. T15 expressed (Female, College, ZOOM) this concern, *"If there is a mistake in livestreaming class, it will delay a lot of time. I can't make sure that every student in such a large class have downloaded the same backup software and I also can't tell them one on one to make sure they receive the information and enter into the new class."*

Senior Teachers' Learning Curves. The technology operation challenges were severe for teachers (80%), especially in elder ages or in rural areas. Forgetting to turn on the microphone, accidentally turning off the livestreaming studio, or failing to successfully share the screen; such accidents were mentioned by 7 (46.7%) participants. Their lack of familiarity with digital devices, such as mobile phones or computers, makes them nervous and absorbed in teaching. Additionally, due to the stay-home-order, the organization can't provide face-to-face, one-to-one technical tutoring and support. Considering these challenges senior teachers faced, they had to pay much time and effort to adapt to the online teaching, which caused challenges and mistakes in their livestreaming class. For example, they paid all their attention to speaking and didn't have time to follow the other actions of the students so that students' real-time feedback to the mistakes in the chat-rooms usually couldn't be seen in time. This would make the mistakes last for a long time and hard to recover. T3 (Female, Junior high school, QQ, 41-50) described the mistake she made, *"I spoke to the air for a long time without turning on the microphone in the last course! Then after about 15 minutes, I found that my students did not interact with me at all and then I exited the studio to QQ group, and I saw the children said to me, 'Miss Liu, you did not open the microphone, and we can't hear you!'. I don't know where to open, so that I just randomly clicked on the button above for a long time and finally fixed."*

The unfamiliarity with technology occurs more in the senior teachers in middle school, especially in the underdeveloped areas. Due to the need for daily work, college teachers have more opportunities to use computers and have the need to understand new technologies. Three college teachers said they had experience in online teaching. However, as for middle school teachers, they have been used to the traditional offline teaching method, and their information literacy was at a low level. Thus, almost all of them had no experience in online teaching. It is also easier for young teachers to learn to use livestreaming, as they are used to using mobile phones for socializing and entertainment. But for the senior teachers, they have difficulty with typing on the phone or computer, so it took a lot of time and experience for them to learn how to stream. As T2 said (Female, Junior high school, QQ, 41-50), *"It took me about a whole weekend to learn how to stream on Tencent Class in PC, which was too complicated for me. The buttons dazzled me and finally I gave up and choose teaching in the group chat in QQ by video calling on the mobile terminal. I can't remember much operations; I can only learn the basics."* Senior teachers can only use familiar social platforms,

such as QQ, for teaching, and they only need just one click on the familiar platform to open live video streaming class. However, other auxiliary functions, such as interactive activities in class, group discussions and real-time homework, were too difficult for them to learn. As a result, senior teachers' learning curves would experienced a steep acceleration at the beginning when they started to learn how to start a livestreaming class but it plateaued as soon as they acquired basic functions.

Swinging Moods For teachers, emotions such as resistance to online teaching, fear of technology adoption, and frustration with the difficulty of motivating students have been mentioned in previous studies. These findings have also been confirmed in our study. We can find that negative emotions for teachers were easily affected by their performance and their students' performance in class. Some teachers (33.3%) expressed nervousness before class. T7 was so anxious before class that she could not get a good night's sleep. The reason she was so nervous was because of the uncertainty of the live broadcast technology. She was worried about the operation mistakes in the live broadcast class, which would affect the students' class experience. She got up two hours earlier to prepare for the class; compared to that she spent 30 minutes for in-person classes. It was difficult for her to speak in front of a camera, because she needed to write down what she was going to say in advance. Therefore, the increased pressure at work caused severe mood swings. There are also teachers whose emotions were affected by the performance and attendance of students in the class. Whether students enter the LVS-based class on time, whether students actively engage in and give useful feedback, can all affect their emotional experience. T2 (Female, Junior high school, QQ) expressed her emotional swings, *"I get really upset every time I see only 60 kids show up in the live studio because there should be more than 100 students in my livestreaming class. I felt like my efforts were in vain, and the students didn't care."*

The Lack of Help from Parents. In our study, the role of parents in the online education context was also mentioned many times by teachers from K-12 education. Most primary and middle school students needed to accept parental supervision due to lack of self-control, in the stage of family learning. Many teachers complained that the parents' control was not enough, and they did not help the children finish the homework on time as required by the teachers. During distance learning, children who did not have mobile phones had the opportunity to use their parents' mobile phones, but the lack of parental supervision led to the fact that mobile phones were not actually used in study. For example, as T3 (Famale, K-12, QQ) said, *"I found that some children played games on their parents' phone for all day long. I heard the sound of games when I asked the student to open his audio. I connected his parents and discussed this problem with them, but it didn't work."* Some teachers especially mentioned the serious conflicts between their children and their parents when they were studying at home. For example, T13 (Famale, K-12, Bilibili) said, *"A parent called me and said that he had quarreled with his child, and the child left home and went to a classmate's home, so he could not finish his study and submitted his homework on time."* Family environment was an important factor affecting distance learning, which was difficult for teachers to address.

4.1.4 Unique Challenges for Students. Peer Presence is the most important unique challenge for students.

Lack of Peer Presence. Some of our student participants are middle school students; three facing the college entrance examination, and two facing the high school entrance examination. They were all anxious about the form of online learning. The learning style of staying at home for a long time makes them unable to perceive the learning level of other students and also reduces their learning efficiency, so they have been in a state of anxiety for a long time. S14 (Female, High school, Tencent conference) expresses her anxiety about this, *"I used to be able to see the study status of the students around me in school. Still, now I am always learning alone, which makes me*

very anxious. I really want to go back to school, I'm afraid that the long-term online study will affect my score to a good university." Because they learn through livestreaming, it was difficult for them to get the same quality of courses as offline, and it was also difficult for them to concentrate. Low self-control made it hard for them to study effectively at home so that almost all of the high school students' grades were affected. As S15 (Female, High school, Tencent conference) said, "*Without my classmates around, I feel less competition and peer pressure, so that I have no self-control to consciously learn. My study time and my study efficiency were reduced. And in the recent exams, my ranking had dropped.*"

4.2 Stakeholders' Practices of Addressing the Challenges (RQ2)

In general, teachers and students emphasize the challenges and difficulties in the transition from offline to online livestreaming, but they hardly think about how to solve these problems. Based on the interview data collected one month after the transition, some challenges have been alleviated to some extent by the self-developed way of some interviewees. We also found that compared to conflicting challenges, unique challenges that involve few stakeholders were easier to solve. The problems that both stakeholders face, either shared or conflicting, are more challenging to solve. So we present some solutions to the challenges above in this section. Although these methods are the practice of individual teachers and students, they reflect the efforts of teachers and students to adapt to the transition.

4.2.1 Addressing Shared Challenges for Teachers and Students. For shared challenges, the trust issue, the missing body language and the lack of real-time feedback are inherent problems in online teaching, which have not been solved so far. Teachers and students use the beauty camera and virtual backgrounds to alleviate the concern about impression management.

Using Beauty Camera for Impression Management. The beauty effect of the camera can mitigate the challenges of impression management to some extent. Some young teachers (T8, T13) and female students (S1,S2) have tried this during the streaming course. As T13 (Female, High school, Bilibili) said, "*I think the reason I don't like to turn on the camera is that I don't think I look pretty and I'm too messy at home. However, after the beauty camera is opened, I do not care about presenting myself. Especially during the course in the afternoon, because the sun comes in at that time, it will look like my skin is perfect; I feel confident about it.*" This function can help students and teachers show themselves in front of everyone with confidence without makeup. In addition, to avoid exposure to the home environment, many platforms have developed the function of virtual background. The feature was first used by ZOOM, while local platforms in China such as Tencent Conference have added this feature. In this way, the furniture or decoration at home will no longer be captured by the camera, which can relieve some teachers' and students' anxiety about family impression management. As S13 (Male, College, Tencent Conference) said, "*I like use the virtual background in the app. This can protect my home environment from being exposed. Family members also would not be caught if they passed by.*"

4.2.2 Working with Conflicting Challenges for Teachers and Students. By using entertainment functions and creating anonymous forums, teachers can solve conflicts on engagement to some extent, to enhance efficient engagement and balance between entertaining and teaching. However, the difficulties in choosing and switching between multi-platforms have not been solved by our participants.

Engaging the Class with Red Envelope Functions To stimulate students' enthusiasm and make the class more entertaining and interesting, some teachers re-purposed entertainment features in livestreaming platforms, especially using the method of giving red envelops . They found that giving red envelopes can attract students' attention quickly and it wouldn't take too much

time. And the activity of grabbing red envelopes is rich in fun, which can effectively relieve boredom in class. This approach provides a good balance between entertainment and teaching, as T8 (Male, College, Chao Xing) mentioned, *"I handed out a red envelope when I felt the students' attention began to wander, and few people were willing to participate in the interactive discussion. Then the students will start to grab the red envelopes so that they will be more excited and their attention will return to the class."* From the perspective of students, the red envelope, as a reward, is encouraging and positive feedback from the teacher. As S17 (Female, Junior high school, DingTalk) said, *"The red envelope is a kind of praise given by my teacher and a reward for my active participation in class activities. Therefore, I am very proud to receive the red envelope."* In addition, the rewards in the red envelope are random, so driven by unpredictability and curiosity, when students participate in grabbing the red envelope, they can feeling a sense of gamification in class.

Creating Anonymous Communication Channels. Some teachers found that students were reluctant to speak in front of others and afraid of making mistakes when answering questions. One of them (T11 - Male, College, Rain Class and QQ) solved this problem by developing an anonymous platform, which is of great significance for reference. He allowed students to send their answers anonymously to the comment box during the class so that students would not be ashamed of their wrong answers. When he adopted this method, the number of students participating in the in-class discussion of answers increased significantly. He also set up an anonymous forum as a platform for after-class discussion, where students can provide comments and feedback on the course at any time, *"I set up an anonymous forum for them to express their ideas on the platform more freely. Some questions or ideas are very valuable, which I never seen offline."*

4.2.3 Seeking Support to Address Teachers' Unique Challenges. For teachers, the technical problems they encountered at first were gradually solved, such as being unfamiliar with the technology and being afraid of making mistakes. And the emotional fluctuation has been also decreased as they became more familiar with online teaching. In general, most of the challenges unique for teachers have been addressed.

Senior Teachers Receiving Support from Family and Colleagues. Family and colleagues' support is the most effective way to address the technical challenges of livestreaming. Eight senior teachers (53.3%) mentioned the great help their children had been in learning how to use the livestreaming platforms. These teachers are generally between 40 and 50 years old, and their children are mostly in college. Their children took on multiple tasks such as platform selection, operation guidance, accident and problem-solving, and equipment provision to help teachers to instruct online. As T7 (Female, Junior high school, Tencent Class) said, *"It was my daughter who taught me how to conduct livestreaming course step by step. My daughter sat next to me during the live course to help me with any problems that might arise. If she were not at home this time, I would feel stuck, and maybe I couldn't finish teaching online."* Some teachers addressed the technical uncertainty through trialing in small groups with colleagues. Several teachers in a small group opened the studio on the platform where they were going to broadcast, and they learned how to use every function in the software to improve the proficiency and solve the possible accidents during livestreaming. Like T3 (Female, Junior high school, QQ) said, *"Together with some of my colleagues, we set up a small group in QQ. Then we started experimenting with various features. At night before the first class, we continuously launched livestreaming, communicated and learned from each other."*

4.2.4 Students Handling Their Unique Challenges. For students, long-term emotional problems caused by online livestreaming can be solved through effective communication with classmates. Students haven't yet to come up with a solution to the contradiction between their unwillingness to reveal themselves and having more interaction in class, which correlates with more profound psychological and cultural factors behind this problem.

Offline Engagement with Classmates. More communication between classmates can relieve the negative feelings of students in the transition from offline to online. Such communication can take many forms, not just in language. Some students will communicate with their classmates about the class contents in the group chat in real-time, which can help them understand the learning level of others and improve their perception of social presence and help them understand the knowledge, to enhance their cognitive presence.

In order to solve the anxiety caused by not knowing others' study status, some students spontaneously set up study groups. They used productivity software to track how much time they spend on studying each day, and the group members can see each other's study time and specific learning content, as S15 (Female, High school, Tencent Conference) described, *"Our group used Tomato Clock to study together, which made me feel very motivated, just like studying with my classmates in school. Because the software will show the specific content of each person's study in a certain period, I can clearly perceive the status of my classmates, which reduces my pressure."* Students also said that more group work needed to be done during the online learning process. Like S16 said, (Male, Junior high school, DingTalk), *"Our teacher would ask two students to form a mutual-help group. We needed to report what we did to each other every day. We also need to monitor each other's study; if the other does not complete the homework, my grades will be affected."*

4.3 Prospects of LVS-based Online Education (RQ3)

We also summarized the prospects of LVS-based online education. For teachers, LVS-based teaching brings them a positive emotional experience, bringing them closer to students. The entertainment functions make students more active to engage. These benefits make them more active in considering applying blended teaching in the future. For students, the equality between teachers and students has increased, and it is convenient for them to take notes and review. It also increases communication efficiency between K-12 students and teachers through text-based messages.

4.3.1 Creating Overall Positive and Encouraging Emotional Experiences for Teachers. Although we mentioned that the teachers experienced swinging moods at the beginning of online teaching, after conducting live video streaming teaching for a while, the teachers started experiencing a positive emotion, and the main reason for this transition was their acquisition of new technology, the increasing engagement of students, and the increasing intimacy of the teacher-student relationship.

First, teachers' positive emotional experiences came from the acquisition of a new teaching method and technology during the transition to online, which lessened their fear of uncertainty and increased their confidence in technology adoption. At the beginning, most of the teachers were skeptical about the livestreaming course, but as they became familiar with it, they started to feel the positive outcomes of implementing new technology in teaching. As T1 (Male, Junior high school, DingTalk) said, *"I used to be very averse to the computer. Although when I first heard the require of online teaching, I was afraid I wouldn't be able to learn. But in fact, these things are not as difficult as imagined, so I am now with the attitude of lifelong learning."* In addition, some teachers initially had a strong aversion to live classes, but after a month or two of trying, they now feel a strong sense of achievement despite overcoming a lot of hardships in the process. Like T7 (Female, Junior high school, Tencent Class) experienced, *"When I first heard about the informs, I was really angry, even disgusted. But then I slowly began to learn, and I felt calmer. Now that I can conduct live class on my own, I'm actually proud of myself. I used to think it was magical for stars to make live show on TV. Now I can also become a live streamer, and I can do better than them!"*

Second, the students' gradually increased engagement also gives teachers encouraging feedback. T15 (Female, College, ZOOM) shared her positive emotional experience with an unexpected level

of student engagement: *"The students in our school really amaze me! I was prepared for the worst, because I thought there were all kinds of reasons why students might be absent from live course. But one time I asked a question, and a student seemed to be in the toilet, but he didn't turn off the livestreaming and was still answering my questions. I think the attendance of the students really warmed me up."* Some entertainment functions in social media can also help improve engagement as well as increase the teacher's sense of self-worth. As T7 (Female, Junior high school, Tencent Class) said, *"Children gave me flowers and presents in livestreaming, which makes me feel I'm doing something worthwhile."* Younger teachers were more familiar with using entertainment in streaming. They perceived the streaming practice to increase their intimacy with students, reduce the generation gap between teachers and students, and to greatly improve student interest and real-time feedback. T14 (Female, College, QQ) gave an example, *"I will use some lingo of livestreaming in class, such as "come a wave of gifts", "double-click 666" and so on. The students also have fun, and they would send me a yacht manually (often as a gift to in livestreaming platforms, which is an important part of the income source of the streamers)."* Danmaku is also an interesting way to communicate with teachers and other classmates and welcomed by students. They preferred to use Danmaku to express their ideas anonymously, rather than speaking in traditional class.

Third, the increasing intimacy between teachers and students, and even parents, can also bring positive emotional experience to teachers. After online streaming sessions, teachers and students usually communicated with each other through other social media apps with instant messaging functions, such as WeChat and QQ. After adding each other as friends, they can view each other's and user-centered personal logs. Therefore, teachers get a chance to learn more about students' ideas and lives through social platforms. Some teachers took the initiative to adopt some interesting ways to increase intimacy with students in class, such as T11, who encouraged students to send photos of breakfast in a group chatroom as a way to sign in. Closer ties with parents have also been a feature of the transition. Most middle school teachers think there was more online communication with parents, which helps them to know students better. T12 talked about inviting parents and children to have PE class together, and such activities were also mentioned by S12, S13 and other college students.

Fourth, another advantage of streaming is in-class real-time statistics, which cannot be achieved offline. Teachers could publish multiple choice questions or essay questions through professional teaching platforms, e.g., Rain Class, and these platforms would conduct real-time statistics on students' answers and quickly form reports, e.g., answer distribution and word cloud map. The teacher can quickly adjust the teaching content according to the statistical results. As T11 (Male, College, Rain Class and QQ) acclaimed, *"I can directly post the questions in the livestreaming, and the students can directly choose the answers, then I can immediately get feedback to see how many students do wrong and how many do right, so I can know their problems and adapt my teaching pace."*

Last but not least, teachers started to actively consider using blended teaching in the future. Many teachers have mentioned that they would consider tutoring students through Live Video Streaming after returning to offline teaching. This has changed the traditional teaching mode to a great extent and brought opportunities for the development of blended teaching. Several teachers considered this emergency transition for them to go out of their comfort zone, enhance their technological skills and reflect on past teaching experience. As T13 (Female, High school, Bilibili) said, *"Actually, our school has been thinking about how to help teachers learn new technologies and combine online and offline so as to achieve blended teaching, but there is a great resistance to reform. Without this outbreak of virus, teachers would not have been able to accept livestreaming so quickly."* The skills needed to conduct online teaching was not as hard as they first expected. And the proximity they imagined to exist between them and their students was low. The learning outcome of conducting

Fig. 5. Flat vs. Hierarchical Structure-ClassIn

was even better than their expectations. Using livestreaming platforms for Question and Answer sessions in accompaniment to offline learning is likely to achieve better learning efficiency.

4.3.2 Promoting Learning Experience for Students. First, students can perceive more equality and less hierarchy between teachers and themselves because of the flat structure in some live video streaming platforms.

In general, videoconferencing have a flat structure while livestreaming platforms have a hierarchical structure. However, sometimes this structure in videoconferencing and some professional teaching platform can be changed manually.As Figure 3 shows, the professional platforms classIn, which has a similar view with videoconferencing system, could be used in both flat and hierarchical structure. Teachers and students in China were more used to adopting hierarchical view, in which teachers are the "streamers," and students are the audience. It is aligned with the traditional teacher-centered relationship between teachers and students in China, where the teacher is positioned either up front in the classroom or is located as the very first in the profile display, illustrated in Figure 5. Students can see teachers, but teachers can only perceive students through text comments or audio required by students. Although these platforms provided video windows for students, their windows were often closed or their cameras were turned off by the teachers to make sure the teachers were the focus. Some teachers often restricted students' rights and did not allow students to open the video and audio at will, so the original flat structure becomes hierarchical, illustrated in Figure 5. Although many teachers adopted a hierarchical structure, students still felt that the gap between teachers and students has become smaller. As S2 (Female, College, ClassIn) said, *"Watching the teacher through the live video streaming is like watching the live game streaming. Although I am restricted to use some features, I still feel more free and relaxed compared with offline."*

On the other hand, in a flat structure, for example, ZOOM and Tencent Conferencing, teachers' faces and names are parallel to students' faces and names. In this case, teachers no longer have a strong sense of authority and pressure as in the offline setting, but bring students the feeling of equality. Such shifts in teacher and student identity may affect in-class activity. Under the relaxed classroom atmosphere and with less pressure, students can better express their views, which may be meaningful for the construction of the relationship between teachers and students. As S11 (Female, Junior high school, QQ and DingTalk) said, *"Because the students and teachers have the same size heads windows and they are arranged randomly, it feels very equal. Answering questions is not as stressful as offline, because it's just like talking to someone."* Different from the traditional process of raising hands and standing up to answer questions in class, students can freely communicate with teachers by just opening audio in LVS-based courses, which reduces the pressure on them to

answer questions. In addition, the flat structure gives students a sense of responsibility as the host of the class. They are no longer just the audience, but can exchange identities with the teacher and become "streamers."

Second, additional channels have been established for K-12 students to communicate with teachers no matter when and where through Text-based Message, especially through private chat. This is very important for K-12 students. All of the 7 K-12 students we interviewed said that livestreaming makes it easier to ask questions. If they encounter a difficult problem, they can ask the teacher through social media, which is more convenient than waiting in line physically to ask questions. As S15 (Female, High school, Tencent Conference) said, *"We senior high school students usually need to queue for long time to ask questions offline. But now I can directly send questions to the teacher, even the teacher was so busy that he did not reply immediately, he will reply me in a while. What's more, the teacher can deepen my understanding of the problem through the way of text answering."* They appreciated the opportunity to chat with teachers privately so that they could receive more personalized instruction and tutoring, which also can help them to communicate with teachers more intimately and deeply.

Third, using text message or Danmaku can promote student's motivation to engage in class. Students liked having interactions with teachers and other classmates, but they didn't want to speak up in audio and reveal themselves in a livestreaming course. Many students (55.5%) said in interviews that they prefer to interact in text form rather than with audio. Since more than one person can send text comments at a time, they didn't have to deal with the psychological burden of being focused. Other students never interacted with the teacher in livestreaming class, but they would choose to communicate with the teacher privately by social media after class. When teachers carried out in-class activities, students often fell into a state of ambivalence. On the one hand, they expected to have communication with teachers; on the other hand, they didn't like to reveal themselves in front of a large number of people by opening up audio. Cultural factors may explain the contradiction. As S9 (Female, College, ZOOM) described, *"I think Chinese students are not used to revealing themselves in public, and they are not used to being the focus of many people. I like to send text answers than opening the microphone, and text make me feel free. I think all the students' attention is on me when speaking, if I answer wrong, it will be very ashamed."*

5 DISCUSSION

We presented the challenges for instructors and students in carrying out LVS-based online teaching and how they addressed these challenges during the sharp transition. By connecting our findings with prior literature, we provide suggestions and design implications to improve future practice. In the first section, we discuss our findings and implications specific to the use of LVS-based online teaching. We then discuss insights on developing educational technologies in general.

5.1 Using LVS-Based Social Platforms for Online Education: Why and How

5.1.1 Improving Relationship Building and Sense of Equality by Using Social Media Features of LVS-Based Platforms. Specific to the Chinese culture and context where student-teacher ratio is high and there is usually an explicit hierarchy between teachers and students [104], classrooms tend to be teacher-centered, with a pedagogical culture based on "passive transmission" and "rote drilling" [104]. The relationship between teachers and students is difficult to bridge, and it is normal for Chinese students to be estranged from their teachers, e.g., they are afraid to ask questions or raise their hands to express themselves in class [104]. Our findings show that using social media features, such as memes and emojis of LVS-based apps improved intimacy between teachers and students. The entertainment functions in the livestreaming platforms, such as sending virtual gifts, can enhance teachers' understanding of students.

Many students appreciated the 'flat structure' in videoconferencing systems. They felt a sense of equality when participating in the online classes. A flat video presentation can also narrow the distance and decrease the sense of hierarchy between teachers and students [64].Lawson also [57] found that videoconferencing tools increased the perceived equity in students by assuring that everyone is receiving the same quality of information. Our findings are consistent in surfacing students' perceived equality and increased intimacy when using videoconferencing tools. However, only a few teachers we interviewed were aware of such students' needs and made good use of it to create a more effective online learning experience. Future use of LVS-based teaching could emphasize on relationship building between teachers and students, and offering a flat and equal experience for students.

As suggested in prior work, social presence and connection with peers is critical for student success in online courses [24, 97]. Synchronous meetings help students develop a sense of community[51]. Future practitioners need to be aware of students needs regarding social connection with peers, equal access to information, and relationship building with instructors. These needs can drive the design of new technologies that promote student engagement, intimacy between instructors and students and education equality.

5.1.2 Promoting Online Education Access through LVS-Based Mobile Learning. Our findings show that enabling online teaching and learning through mobile platforms lowered the threshold for students to participate in online education. Supporting teachers to use LVS features from familiar social media and video streaming platforms also reduced the learning curve for teachers to prepare for online teaching.

Although online education was adopted rapidly in developing countries in recent years, it is still used as a supplement to traditional face-to-face education. The popularization of online education still faces many challenges, as a result of unreliable internet conditions [2], low ICT literacy [4], poor equipment supplies [106], and limited technical training of teachers and students [107]. For example, previous research argued that teachers need to be equipped with advanced equipment such as computers and cameras to complete recording, editing, uploading, and other work [106]. But few of these devices are widely available in developing countries, especially in rural areas. Most livestreaming platforms are supported by the rapid development of 4G mobile networks [60], such as Tiktok, which provides a good opportunity to democratize online teaching through mobile-based live video streaming, especially for primary and middle school. Some practices of connecting K-12 schools in developed and undeveloped areas through video conference has been proven to support students' growth effectively and promote the sharing of quality educational resources [100]. Children in remote areas can learn through live broadcast, receiving the same educational support as the top school in tier-1 cities in real-time and obtain better educational resources.

From our results, we can see that platforms that allow PC only access are relatively less popular among teachers and students (see fig.3), and mobile devices require a lower learning curve for teachers. We observed that teachers find learning and adopting a new teaching software is challenging [95] compared to using the LVS features in existing platforms that they are familiar with, such as QQ. Our work also suggests that LVS alone is not enough for effective and continuous communication between teachers and students. Prior work shows that streamers and viewers often use multiple channels to communicate [58]. In our work, we found that instructors and students appreciate the use of instant messaging tools and social media platforms such as Wechat and QQ for better communication. These tools allow teachers to have private one-on-one chat with students after class and get feedback in time.

5.1.3 Advancing Training Programs to Better Prepare Teachers for Blended Teaching. The unique context of this research lies in the sharp transition; due to the rapid and global pandemic, online education was the only option and no face-to-face interaction was allowed. This unique context brought us many insights that were not possible in prior studies. As our results show, instructors and students undergo a struggle when first transferring to online learning, however many teachers became satisfied with the experience and outcome. Instructors learned new teaching skill-sets, and students consciously developed self-efficiency and equality in learning. Past studies have shown that combining online with offline education would scale-up of the use of online communities for teachers' professional development [62].

Current literature calls for better pedagogical training when transitioning from offline to online [77], and technical problems remain significant challenges for the instructor to adopt the technology of online teaching [106]. In our research, we find that preparing teachers pedagogically and technically for dealing with emerging teaching issues is necessary, e.g., Internet/Platform crash, camera fear, and manipulating multiple platforms at the same time. Especially when extra challenges/cognitive load are needed to manage technology and class engagement, they often can't switch between different modalities, channels or platforms for efficient communication.

Existing literature mostly focused on emotional changes in students when attempting to understand the low use of classroom technology [6, 13, 79], but very rarely on emotional changes on teachers. Our study shows that when adopting new educational technologies in teaching practice, aside from more time needed to deal with pedagogical changes [13], teachers' emotional changes, such as camera fear, should also be considered. Especially when conducting teaching online, how social sectors of online communities influence teacher emotions and behaviors should not be overlooked. Our research findings could be used to develop training programs that help instructors and students understand the pros and cons of online education and strategically develop blended education opportunities in the future. Our study shows that senior teachers receive technical and emotional support from families and colleagues. Prior work on online communities has shown that members stay longer in these communities when they receive social support from peers [19, 103]. Future work could explore community building efforts to further support teachers.

In addition, because several benefits of online teaching can be perceived by teachers when they were forced to conduct online teaching during this transition, education systems may consider requiring teachers go through online teaching for a period of time as part of their training. This can be regarded as a fire drill preparing for certain emergencies, such that teachers are better prepared psychologically and strategically in future unexpected situations; they can also improve their pedagogical approaches by reflecting on the effects of using different communication tools and gain experience engaging students in varied modalities.

5.1.4 Introducing Better Image, Privacy, and Copyright Protection Programs for Teachers. Prior work has shown that opening the camera can increase the interaction and social presence in online education [56]. We expected that students and instructors would be positive about turning on the camera when using LVS platforms. However, we surprisingly found that both of them, especially teachers, face the challenges of camera fear, worrying about personal appearance, and disclosure of their physical environment. Existing studies have explored the considerations around impression management when using social networking sites such as Facebook [50], including self-esteem, self-presentation, etc., which are consistent with our findings. Compared to impression management with photo taking or video shooting [75], it is even more intense in live videos. We found that the beauty function can help alleviate concern about personal image exposure, which is consistent with previous research on taking selfies [75].

The trust between teachers and students is further challenged when transitioning to online teaching. For example, teachers are concerned that their videos and images may be uploaded online by their students so that more people will see how they behave in class. On the one hand, this kind of alertness persuades them to perform better impression management, e.g., they would behave more properly and avoid potential information leakage by manually removing automatically recorded livestreaming videos from platforms. But on the other hand, their emotion could be easily affected by the uncertainty of how their data will be used, which could potentially harm their teaching [102]. Prior research on video privacy and the effect of video surveillance could explain some teachers' reactions to livestreaming [12, 82]. Although we have not yet seen a reliable solution for building trust between teachers and students in online environments, our study surfaces this as a critical issue. We encourage future online education research to design interventions to help trust-building between teachers and students, and guarantee that teachers have a safe and comfortable environment in which to conduct teaching activities..

At the same time, we surface teachers' copyright concerns. The copyright issue of online education has long been discussed [40]. This question has been relatively less considered in the context of live online learning. We can see from existing research that the concept of livestreaming of live sports has changed the legal landscape regarding copyrights, e.g., sports broadcasting [43]. However, since livestreaming based online teaching has just come to people's eyes, there have not been formal regulations around LVS based online teaching. In our study, many teachers are worried about their copyrights and don't want their course materials to be uploaded to the public cyberspace. The lack of copyright protections negatively affects teachers' trust in the platforms when transitioning from offline to online education. Future researchers and practitioners should take a more serious attitude and provide timely support and help.

5.2 Design Implications for Educational Technologies

5.2.1 Augmenting Student Presence. Student attendance is a frequently used measure on student engagement. Research in distance education and MOOCs has been concerned with student attendance issues [46, 97, 101]. Some existing LVS-based online teaching systems, such as Ding-Talk, provide teachers with student activity data, including class attendance, page views, etc. However, the existing data does not provide teachers with a full picture on student engagement. According to teachers in our study, they missed real-time feedback from students to gauge their engagement when transitioning to teaching online, e.g., eye contact and body movements. Participants said such cues were essential for them to adjust their teaching in real-time. Similarly, our student participants also mentioned that they missed the "kindness and supportive eye contact" from teachers. In addition to teacher-student interaction, peer interaction is also critical to keep students engaged [78, 93]. Based on these findings, we suggest future work could explore ways to augment student and teacher presence to facilitate real-time interaction and feedback. W e also propose future directions to provide more informal peer interaction opportunities during online teaching, e.g., informal chat and online forums.

With the rapid development of virtual reality and mixed reality technologies, and bandwidth expansion, recent research has shown its reliability to detect and simulate not only precise real-time body movements, but also facial gestures and expressions [26]. For example, Lumilo [35] uses virtual reality technologies that show real-time student learning analytics on a teacher's VR glasses, Edusense [3] gives teachers feedback on their body language through camera detection using computer vision algorithms. These techniques are currently used in physical classroom settings; future research may consider developing virtual and mixed reality techniques that enhance student presence and provide real-time feedback to teachers when teaching online.

5.2.2 Involving Students, Teachers and Parents in Co-Design of Technologies. Co-design, orientating from participatory design, has shown that the process of developing agency is essential for participant-designers to provide better pragmatic results and to encourage citizenship [44]. Studies have shown that researchers partnering with parents and children in the design process can be important for producing technologies that consider the rich context of family life [99]. A team-based co-design process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, can unfold tensions within the process and resolve them over time [72]. Teachers are generally frustrated by the lack of face-to-face contact with students in online settings, leaving them helpless. These high school teachers want parents to take responsibility and build a better ecosystem of home-school partnerships. As we can see, the online learning system involves multiple stakeholders, instructors, trainers, students, parents, etc. Future research needs to build the ecosystem for engaging in online-learning technologies, then to understand how interpersonal relationships in the ecosystem shape designing processes and how they are reshaped through technology.

5.2.3 Creating a Safe Teaching and Learning Environment. Given the fast speed of transferring information through live-video streaming, in-time information safety issues need to be addressed to create a reliable learning environment. From past research, solicitations were more commonly reported via instant messaging (43%) and in chat rooms (32%), and harassment was more commonly reported in instant messaging (55%) than through social networking sites (27% and 28%, respectively) among youth [98]. In our study, some LVS apps are aware of such problems, like Bilibili's 'teaching mode,' which blocks all advertisements and overly amusing emojis to prevent students from exposing them to inappropriate information and distractions in-class. Some other platforms have algorithms to detect and notify users of improper language use. As we mentioned in our findings, some teachers expressed being afraid of making mistakes not only for teaching impact but also for imprudent use of language and image. Future LVS system designs could leverage the filtering feature to create a safer instant learning environment.

6 LIMITATIONS AND FUTURE WORK

There are several limitations of this work. First, although we tried to reach a wide range of participants of different ages and regions, teachers and students in primary schools are still not well represented in this study. Existing research shows that parental engagement and the collaboration between the school and home is especially crucial in primary school in online teaching practices [84], so that how teachers engage parents to help children learn through live video streaming at home may bring some new patterns to online LVS-based learning and teaching. Second, because our research is in the unique context of a global pandemic and was conducted on the situation in China, some findings we present have a strong cultural background, which may not totally apply to other contexts. For example, the traditional hierarchical relationship between teachers and students in Chinese culture could be affected by LVS, leading to the prospects of a more imitate and equal relationship. For further works, a more systematic study could be done in different countries and regions, to enhance intercultural understanding, and in a quantitative way with a larger population to complement this exploratory study. In addition, more stakeholders, such as school administrators and system designers, can be included to provide additional perspectives to our findings and reveal new insights. Furthermore, the current study did not investigate specific activities, such as offline assignments, group works, and in-class tests, which are also important components for online education. We expect to explore the challenges of conducting these activities in future work.

7 CONCLUSION

The social, ethical and technical aspects of online education have been widely discussed in prior work, but limited studies have discussed the application of live video streaming in online education, especially in a situation where there is no face-to-face option. Our research explores the challenges, practice and prospects that live video streaming brings to online education. Our findings show that challenges such as real-time interaction and engagement, technical uncertainty, ethical issues such as privacy and copyright, and impression management remain severe in LVS-based online teaching, which are mentioned in other ways of online teaching. However, live video streaming offers more opportunities for online education, including but not limited to increasing intimacy between students and teachers, and entertainment functions that promote participation. This mobile-supported approach helps to narrow the technological accessibility of students from different backgrounds when they transition to online education in this emergency, which promotes educational equality. Our research can provide insights for scholars, system designers, and practitioners to address potential problems in the transition to online education.

8 ACKNOWLEDGEMENT

REFERENCES

[1] M'hammed Abdous and Wu He. 2011. Using text mining to uncover students' technology-related problems in live video streaming. *British Journal of Educational Technology* 42, 1 (2011), 40–49.

[2] Raniah Samir Adham and Karsten Oster Lundqvist. 2015. MOOCs as a method of distance education in the Arab world–A review paper. *European Journal of Open, Distance and E-learning* 18, 1 (2015), 123–138.

[3] Karan Ahuja, Dohyun Kim, Franceska Xhakaj, Virag Varga, Anne Xie, Stanley Zhang, Jay Eric Townsend, Chris Harrison, Amy Ogan, and Yuvraj Agarwal. 2019. EduSense: Practical classroom sensing at Scale. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 3, 3 (2019), 1–26.

[4] Gonzalo Almerich, Natividad Orellana, Jesús Suárez-Rodríguez, and Isabel Díaz-García. 2016. Teachers' information and communication technology competences: A structural approach. *Computers & Education* 100 (2016), 110–125.

[5] Terry Anderson, Krista Poscente, and Liam Rourke. 2006. Perceptions of an impending high speed, broadband network: Anticipation and anxiety among K-12 teachers, technical support personnel, and administrators. (2006).

[6] Zane L Berge and Susan E Mrozowski. 1999. Barriers to online teaching in elementary, secondary, and teacher education. *UMBC Faculty Collection* (1999).

[7] Robert M Bernard, Philip C Abrami, Yiping Lou, Evgueni Borokhovski, Anne Wade, Lori Wozney, Peter Andrew Wallet, Manon Fiset, and Binru Huang. 2004. How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of educational research* 74, 3 (2004), 379–439.

[8] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[9] Kathy Charmaz. 2006. *Constructing grounded theory: A practical guide through qualitative analysis*. sage.

[10] Di Chen, Dustin Freeman, and Ravin Balakrishnan. 2019. Integrating Multimedia Tools to Enrich Interactions in Live Streaming for Language Learning. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–14.

[11] Aimei consulting. 2020. A special report on the evaluation of the effect of the online resumption of Chinese schools in the spring of 2020. https://www.iimedia.cn/c460/69584.html.

[12] Matthew S Crow, Jamie A Snyder, Vaughn J Crichlow, and John Ortiz Smykla. 2017. Community perceptions of police body-worn cameras: The impact of views on fairness, fear, performance, and privacy. *Criminal justice and behavior* 44, 4 (2017), 589–610.

[13] Larry Cuban, Heather Kirkpatrick, and Craig Peck. 2001. High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American educational research journal* 38, 4 (2001), 813–834.

[14] Southern Daily. 2020. Within an hour, 5 million students were streaming into live classes. http://edu.sina.com.cn/zxx/2020-02-23/doc-iimxxstf3734431.shtml.

[15] Guangming daily education research center. 2020. An interactive study on online education in primary and secondary schools during the covid-19 outbreak. http://edu.gog.cn/system/2020/04/02/017570781.shtml.

[16] Paul Diver and Ignacio Martinez. 2015. MOOCs as a massive research laboratory: Opportunities and challenges. *Distance Education* 36, 1 (2015), 5–25.

[17] Audubon Dougherty. 2011. Live-streaming mobile video: production as civic engagement. In *Proceedings of the 13th international conference on human computer interaction with mobile devices and services*. 425–434.

[18] Michaelanne Dye, David Nemer, Neha Kumar, and Amy S Bruckman. 2019. If it Rains, Ask Grandma to Disconnect the Nano: Maintenance & Care in Havana's StreetNet. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–27.

[19] Brianna Dym, Jed R Brubaker, Casey Fiesler, and Bryan Semaan. 2019. "Coming Out Okay" Community Narratives for LGBTQ Identity Recovery Work. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–28.

[20] Sina education. 2020. The epidemic has affected the online education industry. http://edu.sina.com.cn/l/2020-03-10/doc-iimxyqvz9292648.shtml.

[21] The education ministry in China. 2020. Organize and manage online teaching in colleges during the epidemic. http://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/s5987/202002/t20200205_418131.html.

[22] Travis Faas, Lynn Dombrowski, Alyson Young, and Andrew D Miller. 2018. Watch me code: Programming mentorship communities on twitch. tv. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (2018), 1–18.

[23] Samantha Finkelstein, Evelyn Yarzebinski, Callie Vaughn, Amy Ogan, and Justine Cassell. 2013. The effects of culturally congruent educational technologies on student achievement. In *International Conference on Artificial Intelligence in Education*. Springer, 493–502.

[24] D Randy Garrison, Terry Anderson, and Walter Archer. 1999. Critical inquiry in a text-based environment: Computer conferencing in higher education. *The internet and higher education* 2, 2-3 (1999), 87–105.

[25] Donald Gillies. 2008. Student perspectives on videoconferencing in teacher education at a distance. *Distance Education* 29, 1 (2008), 107–118.

[26] S Greenwald, Alexander Kulik, André Kunert, Stephan Beck, B Frohlich, Sue Cobb, Sarah Parsons, and Nigel Newbutt. 2017. Technology and applications for collaborative learning in virtual reality. (2017).

[27] Lassi Haaranen. 2017. Programming as a performance: Live-streaming and its implications for computer science education. In *Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education*. 353–358.

[28] William A Hamilton, Oliver Garretson, and Andruid Kerne. 2014. Streaming on twitch: fostering participatory communities of play within live mixed media. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 1315–1324.

[29] Erik Harpstead, Juan Sebastian Rios, Joseph Seering, and Jessica Hammer. 2019. Toward a Twitch Research Toolkit: A Systematic Review of Approaches to Research on Game Streaming. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. 111–119.

[30] Wu He. 2013. Examining students' online interaction in a live video streaming environment using data mining and text mining. *Computers in Human Behavior* 29, 1 (2013), 90–102.

[31] Khe Foon Hew and Wing Sum Cheung. 2014. Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational research review* 12 (2014), 45–58.

[32] C Ho and C Yang. 2015. A study on behavior intention to use live streaming video platform based on TAM model. In *The Asian Conference on Psychology and Behavioral Sciences 2015*.

[33] Charles Hodges, Stephanie Moore, Barb Lockee, Torrey Trust, and Aaron Bond. 2020. The difference between emergency remote teaching and online learning. *EDUCAUSE Review. https://er. educause. edu/articles/2020/3/the-difference-between-emergency-remote-teachingand-online-learning* (2020).

[34] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. 2017. Intelligent tutors as teachers' aides: exploring teacher needs for real-time analytics in blended classrooms. In *Proceedings of the seventh international learning analytics & knowledge conference*. 257–266.

[35] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. 2018. Student learning benefits of a mixed-reality teacher awareness tool in AI-enhanced classrooms. In *International conference on artificial intelligence in education*. Springer, 154–168.

[36] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. 2019. Designing for complementarity: Teacher and student needs for orchestration support in ai-enhanced classrooms. In *International Conference on Artificial Intelligence in Education*. Springer, 157–171.

[37] Stefan Hrastinski. 2006. Introducing an informal synchronous medium in a distance learning course: how is participation affected? *The Internet and Higher Education* 9, 2 (2006), 117–131.

[38] Stefan Hrastinski. 2008. Asynchronous and synchronous e-learning. *Educause quarterly* 31, 4 (2008), 51–55.

[39] Xiao-qin HUANG and HONG Wien. 2017. Live Streaming Teaching Applied in Real English Classroom. *DEStech Transactions on Social Science, Education and Human Science* aems (2017).

[40] Kristine H Hutchinson. 2003. The teach act: Copyright law and online education. *NYUL Rev.* 78 (2003), 2204.

[41] EO Intelligence. 2020. An analysis of the impact of covid-19 on the education industry. http://www.199it.com/archives/1030767.html.

[42] Anbareen Jan. 2020. Online Teaching Practices During COVID-19: An Observation Case Study. (2020).

[43] Kanchana Kariyawasam and Matthew Tsai. 2017. Copyright and live streaming of sports broadcasting. *International Review of Law, Computers & Technology* 31, 3 (2017), 265–288.

[44] Finn Kensing and Jeanette Blomberg. 1998. Participatory design: Issues and concerns. *Computer supported cooperative work (CSCW)* 7, 3-4 (1998), 167–185.

[45] René F Kizilcec, Kathryn Papadopoulos, and Lalida Sritanyaratana. 2014. Showing face in video instruction: effects on information retention, visual attention, and affect. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 2095–2102.

[46] René F Kizilcec, Justin Reich, Michael Yeomans, Christoph Dann, Emma Brunskill, Glenn Lopez, Selen Turkay, Joseph Jay Williams, and Dustin Tingley. 2020. Scaling up behavioral science interventions in online education. *Proceedings of the National Academy of Sciences* 117, 26 (2020), 14900–14905.

[47] René F Kizilcec, Andrew J Saltarelli, Justin Reich, and Geoffrey L Cohen. 2017. Closing global achievement gaps in MOOCs. *Science* 355, 6322 (2017), 251–252.

[48] Kenneth R Koedinger, John R Anderson, William H Hadley, and Mary A Mark. 1997. Intelligent tutoring goes to school in the big city. (1997).

[49] Steve Kolowich. 2013. The professors who make the MOOCs. *The Chronicle of Higher Education* 18 (2013).

[50] Nicole C Krämer and Stephan Winter. 2008. Impression management 2.0: The relationship of self-esteem, extraversion, self-efficacy, and self-presentation within social networking sites. *Journal of media psychology* 20, 3 (2008), 106–116.

[51] Matthew J Kruger-Ross and Richard D Waters. 2013. Predicting online learning success: Applying the situational theory of publics to the virtual classroom. *Computers & Education* 61 (2013), 176–184.

[52] Daniel G Krutka and Kenneth T Carano. 2016. "As long as I see you on Facebook I know you are safe": Social media experiences as humanizing pedagogy. In *Rethinking social studies teacher education in the twenty-first century*. Springer, 207–222.

[53] Daniel G Krutka, Kenneth T Carano, Leigh Cassell, Melissa Lavoie, and Karin Davidson-Taylor. 2019. Wise Practices and Intercultural Understandings: A Framework for Educator Videoconferencing. *Journal of Research on Technology in Education* 51, 4 (2019), 356–376.

[54] Chinmay Kulkarni, Julia Cambre, Yasmine Kotturi, Michael S Bernstein, and Scott R Klemmer. 2015. Talkabout: Making distance matter with small groups in massive classes. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. 1116–1128.

[55] Chinmay Kulkarni, Koh Pang Wei, Huy Le, Daniel Chia, Kathryn Papadopoulos, Justin Cheng, Daphne Koller, and Scott R Klemmer. 2013. Peer and self assessment in massive online classes. *ACM Transactions on Computer-Human Interaction (TOCHI)* 20, 6 (2013), 1–31.

[56] Tony Lawson and Chris Comber. 2010. Videoconferencing in English schools: one technology, many pedagogies? *Technology, Pedagogy and Education* 19, 3 (2010), 315–326.

[57] Tony Lawson, Chris Comber, Jenny Gage, and Adrian Cullum Hanshaw. 2010. Images of the future for education? Videoconferencing: a literature review. *Technology, Pedagogy and Education* 19, 3 (2010), 295–314.

[58] Zhicong Lu, Michelle Annett, Mingming Fan, and Daniel Wigdor. 2019. "I feel it is my responsibility to stream" Streaming and Engaging with Intangible Cultural Heritage through Livestreaming. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–14.

[59] Zhicong Lu, Seongkook Heo, and Daniel J Wigdor. 2018. Streamwiki: Enabling viewers of knowledge sharing live streams to collaboratively generate archival documentation for effective in-stream and post hoc learning. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (2018), 1–26.

[60] Zhicong Lu, Haijun Xia, Seongkook Heo, and Daniel Wigdor. 2018. You watch, you give, and you engage: a study of live streaming practices in China. In *Proceedings of the 2018 CHI conference on human factors in computing systems*. 1–13.

[61] Michael A Madaio, Fabrice Tanoh, Axel Blahoua Seri, Kaja Jasinska, and Amy Ogan. 2019. "Everyone Brings Their Grain of Salt" Designing for Low-Literate Parental Engagement with a Mobile Literacy Technology in Côte d'Ivoire. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–15.

[62] Uwe Matzat. 2013. Do blended virtual learning communities enhance teachers' professional development more than purely virtual ones? A large scale empirical comparison. *Computers & Education* 60, 1 (2013), 40–51.

[63] C Milligan, A Margaryan, and A Littlejohn. 2013. Patterns of engagement in massive open online courses. *Journal of Online Learning with Technology* 9, 2 (2013), 149–159.

[64] Liz Mineo. 2020. Time to fix American education with race-for-space resolve. https://news.harvard.edu/gazette/story/2020/04/the-pandemics-impact-on-education/.

[65] China national network information center (CNNIC). 2020. Statistical report on Internet development in China(the 43th version). http://www.cac.gov.cn/2019-02/28/c_1124175686.htm.

[66] Eric C Nippard. 2005. *Social presence in the web-based synchronous secondary classroom.* Ph.D. Dissertation. Memorial University of Newfoundland.

[67] Thelma Obiakor and Adedeji Peter Adeniran. 2020. Covid-19: Impending Situation Threatens to Deepen Nigeria's Education Crisis. (2020).

[68] Amy Ogan, Erin Walker, Ryan SJd Baker, Genaro Rebolledo Mendez, Maynor Jimenez Castro, Tania Laurentino, and Adriana De Carvalho. 2012. Collaboration in cognitive tutor use in Latin America: Field study and design recommendations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* 1381–1390.

[69] Murat Oztok, Daniel Zingaro, Clare Brett, and Jim Hewitt. 2013. Exploring asynchronous and synchronous tool use in online courses. *Computers & Education* 60, 1 (2013), 87–94.

[70] Rachael M Paton, Andrew E Fluck, and Joel D Scanlan. 2018. Engagement and retention in VET MOOCs and online courses: A systematic review of literature from 2013 to 2017. *Computers & Education* 125 (2018), 191–201.

[71] Anthony J Pellicone and June Ahn. 2017. The Game of Performing Play: Understanding streaming as cultural production. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.* 4863–4874.

[72] William R Penuel, Jeremy Roschelle, and Nicole Shechtman. 2007. Designing formative assessment software with teachers: An analysis of the co-design process. *Research and practice in technology enhanced learning* 2, 01 (2007), 51–74.

[73] Katarina Pisutova, Rhianna Rogers, and J. Mercer. 2018. Engaging Students at a Distance: Advantages and Pitfalls of Video-Conference use in Teaching. In *2018 16th International Conference on Emerging eLearning Technologies and Applications (ICETA).* IEEE, 431–438.

[74] Drew Polly. 2012. *Developing Technology-Rich Teacher Education Programs: Key Issues: Key Issues.* IGI Global.

[75] Lin Qiu, Jiahui Lu, Shanshan Yang, Weina Qu, and Tingshao Zhu. 2015. What does your selfie say about you? *Computers in Human Behavior* 52 (2015), 443–449.

[76] David Raths. 2015. 6 Ways Videoconferencing Is Expanding the Classroom: With Instant Access to International Collaborators, Virtual Field Trips and Courses in Other Districts, Learning Can Happen Anywhere in the World. *THE Journal (Technological Horizons In Education)* 42, 4 (2015), 12.

[77] Petrea Redmond. 2011. From face-to-face teaching to online teaching: Pedagogical transitions. In *Proceedings AS-CILITE 2011: 28th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Changing Demands, Changing Directions.* Australasian Society for Computers in Learning in Tertiary Education (AS-CILITE), 1050–1060.

[78] Justin Reich, Christopher J Buttimer, Dan Coleman, Richard D Colwell, Farah Faruqi, and Laura R Larke. 2020. What's Lost, What's Left, What's Next: Lessons Learned from the Lived Experiences of Teachers During the 2020 Novel Coronavirus Pandemic. (2020).

[79] Janet Ward Schofield. 1995. *Computers and classroom culture.* Cambridge University Press.

[80] Graduate school of Peking University. 2020. Online teaching arrangement during the spring semester of epidemic prevention and control in Peking University. https://grs.pku.edu.cn/tzgg/326351.htm.

[81] Richard Schwier and Shelly Balbar. 2002. The interplay of content and community in synchronous and asynchronous communication: Virtual communication in a graduate seminar. *Canadian Journal of Learning and Technology/La revue canadienne de l'apprentissage et de la technologie* 28, 2 (2002).

[82] Andrew Senior, Sharath Pankanti, Arun Hampapur, Lisa Brown, Ying-Li Tian, Ahmet Ekin, Jonathan Connell, Chiao Fe Shu, and Max Lu. 2005. Enabling video privacy through computer vision. *IEEE Security & Privacy* 3, 3 (2005), 50–57.

[83] Liping Shen, Minjuan Wang, and Ruimin Shen. 2009. Affective e-learning: Using "emotional" data to improve learning in pervasive learning environment. *Journal of Educational Technology & Society* 12, 2 (2009), 176–189.

[84] Petr Slovák, Kael Rowan, Christopher Frauenberger, Ran Gilad-Bachrach, Mia Doces, Brian Smith, Rachel Kamb, and Geraldine Fitzpatrick. 2016. Scaffolding the scaffolding: Supporting children's social-emotional learning at home. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing.* 1751–1765.

[85] Anselm Straus and Juliet Corbin. 1990. Basics of qualitative research: Grounded theory procedures and techniques.

[86] Na Sun and Mary Beth Rosson. 2017. Finding the community in online education: It's in the instructors' eyes. Philadelphia, PA: International Society of the Learning Sciences.

[87] Na Sun, Xiying Wang, and Mary Beth Rosson. 2019. How Do Distance Learners Connect?. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems.* 1–12.

[88] Jane Sutterlin. 2018. Learning is Social with Zoom Video Conferencing in your Classroom. *eLearn* 2018, 12 (2018), 5.

[89] Tsinghua university news. 2020. The first training for teachers of online streaming teaching in the rain classroom was carried out smoothly in Tsing Hua University. https://news.tsinghua.edu.cn/info/1043/77154.htm.

[90] Alf Inge Wang and Andreas Lieberoth. 2016. The effect of points and audio on concentration, engagement, enjoyment, learning, motivation, and classroom dynamics using Kahoot. In *European Conference on Games Based Learning*, Vol. 20. Academic Conferences International Limited.

[91] Chun-Min Wang and Thomas C Reeves. 2007. Synchronous online learning experiences: The perspectives of international students from Taiwan. *Educational Media International* 44, 4 (2007), 339–356.

[92] Xu Wang, Srinivasa Teja Talluri, Carolyn Rose, and Kenneth Koedinger. 2019. UpGrade: Sourcing Student Open-Ended Solutions to Create Scalable Learning Opportunities. In *Proceedings of the Sixth (2019) ACM Conference on Learning@ Scale.* 1–10.

[93] Xu Wang, Diyi Yang, Miaomiao Wen, Kenneth Koedinger, and Carolyn P Rosé. 2015. Investigating How Student's Cognitive Behavior in MOOC Discussion Forums Affect Learning Gains. *International Educational Data Mining Society* (2015).

[94] Yi-Shun Wang. 2003. Assessment of learner satisfaction with asynchronous electronic learning systems. *Information & Management* 41, 1 (2003), 75–86.

[95] Bing Wu and Xiaohui Chen. 2017. Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. *Computers in Human Behavior* 67 (2017), 221–232.

[96] Man Wu and Qin Gao. 2019. Using Live Video Streaming in Online Tutoring: Exploring Factors Affecting Social Interaction. *International Journal of Human–Computer Interaction* (2019), 1–14.

[97] Diyi Yang, Tanmay Sinha, David Adamson, and Carolyn Penstein Rosé. [n.d.]. Turn on, tune in, drop out: Anticipating student dropouts in massive open online courses.

[98] Michele L Ybarra and Kimberly J Mitchell. 2008. How risky are social networking sites? A comparison of places online where youth sexual solicitation and harassment occurs. *Pediatrics* 121, 2 (2008), e350–e357.

[99] Jason C Yip, Tamara Clegg, June Ahn, Judith Odili Uchidiuno, Elizabeth Bonsignore, Austin Beck, Daniel Pauw, and Kelly Mills. 2016. The evolution of engagements and social bonds during child-parent co-design. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems.* 3607–3619.

[100] Liang Yu and Shijian Chen. 2016. Synchronous remote classroom connecting K-12 schools in developed and undeveloped areas: A case study from China. In *ICT in education in global context.* Springer, 277–291.

[101] Errol Yudko, Randy Hirokawa, and Robert Chi. 2008. Attitudes, beliefs, and attendance in a hybrid course. *Computers & Education* 50, 4 (2008), 1217–1227.

[102] Michalinos Zembylas. 2003. Caring for teacher emotion: Reflections on teacher self-development. *Studies in philosophy and education* 22, 2 (2003), 103–125.

[103] Haoqi Zhang, Matthew W Easterday, Elizabeth M Gerber, Daniel Rees Lewis, and Leesha Maliakal. 2017. Agile research studios: Orchestrating communities of practice to advance research training. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing.* 220–232.

[104] Ningning Zhao, Martin Valcke, Annemie Desoete, Guoyuan Sang, and Chang Zhu. 2014. Does teacher-centered teaching contribute to students' performance in primary school? A video analysis in Mainland China. *International Journal of Research Studies in Education* 3, 3 (2014), 21–34.

[105] Saijing Zheng, Mary Beth Rosson, Patrick C Shih, and John M Carroll. 2015. Understanding student motivation, behaviors and perceptions in MOOCs. In *Proceedings of the 18th ACM conference on computer supported cooperative work & social computing.* 1882–1895.

[106] Saijing Zheng, Pamela Wisniewski, Mary Beth Rosson, and John M Carroll. 2016. Ask the instructors: Motivations and challenges of teaching massive open online courses. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing.* 206–221.

[107] Ye Zheng and Ruo-Yu Yang. 2017. The Rise of MOOCs: The Literature Review of Research Progress and Hot Spots of MOOCs Education in Mainland China. *Eurasia Journal of Mathematics, Science and Technology Education* 13 (08 2017), 6165–6174. https://doi.org/10.12973/eurasia.2017.01056a

[108] Longjun Zhou, Shanshan Wu, Ming Zhou, and Fangmei Li. 2020. 'School's Out, But Class' On', The Largest Online Education in the World Today: Taking China's Practical Exploration During The COVID-19 Epidemic Prevention and Control As an Example. (2020).