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Author(s)	Qiyun Wang, Choon Lang Quek and Xiaoyong Hu
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Designing and Improving a Blended Synchronous Learning Environment: An Educational Design Research



Qiyun Wang¹, Choon Lang Quek¹, and Xiaoyong Hu²

¹National Institute of Education, Nanyang Technological University, Singapore; ²School of Educational Information Technology, South China Normal University, Guangzhou, China

Abstract

In this study, a blended synchronous learning environment (BSLE) was created to support a group of graduate students when they were taking a course. Instruction was delivered to both face-to-face (F2F) and online students simultaneously. The purpose of this paper is to present how this BSLE was gradually designed, implemented, and improved by following the educational design research approach. Results showed that the BSLE environment had the capability to support online and classroom students at the same time and provide equivalent learning experiences for them, but challenges emerged in the process. Design principles were summarized to guide researchers or teachers when they design similar learning environments.

Keywords: blended synchronous learning, blended learning, video conferencing, educational design research, synchronous learning

Introduction

Few people would deny the importance of the classroom as a place for formal learning (Anastasiades et al., 2012). However, people often have to miss classroom instruction in certain situations. For instance, due to family or work commitments, working adults may not be able to attend F2F classes regularly (Gillies, 2008). Because of poor health or bad weather conditions, young students may be prevented from going to school in certain days (White, Ramirez, Smith, & Plonowski, 2010). Furthermore, physically disabled children may never have equal opportunities to go to school as others (Norberg, 2012). It therefore becomes meaningful to explore how to create technology-enabled learning environments that allow people to attend classroom instruction while they are away from the campus.

Asynchronous online learning is often used in the abovementioned situations. But simply making learning resources available online and letting students learn on their own may not work well as learning asynchronously has certain limitations such as the lack of social presence (Han, 2013), delayed feedback (Karal, Çebi, & Turgut, 2011), low participation (Cunningham, 2014), being impersonal (Kear, Chetwynd, Williams, & Donelan, 2015), and low motivation and participation (Hastie, Hung, Chen, & Kinshuk, 2010). One potential way to address the limitations is to incorporate synchronicity into the learning process. In this study, a BSLE consisting of a physical classroom and a virtual learning space was created for the graduate students who were geographically separated from the campus to participate simultaneously in classroom learning activities via computer-mediated communication. The main purpose of the study was to describe how such a learning environment was gradually designed and improved by following the educational research approach. Also, the students' experiences and perceptions of the learning environment were investigated.

Conceptual Framework: Blended Synchronous Learning

Definition

Blended learning often refers to a combination of F2F learning and online learning. They are usually blended in a rotated manner (Staker & Horn, 2012), where a F2F session is carried out in the physical classroom and another is delivered online via technologies such as a learning management system. This is often called blended asynchronous learning. Additionally, F2F learning and online learning can also be implemented in a concurrent way, where a lesson is delivered to both classroom and online students simultaneously, which is called blended synchronous learning in this paper.

In recent years, blended synchronous learning has attracted much attention and it is often labelled with synchronous hybrid learning (Cain & Henriksen 2013); synchronous blended learning (Okita, 2013); multi-access learning (Irvine, Code, & Richards, 2013); or simultaneous delivery of courses to on-campus and off-campus students (White et al., 2010). Adapted from the definition given by Bower, Dalgarno, Kennedy, Lee, and Kenney (2015), blended synchronous learning in this paper is defined as a learning method that enables online students to participate in classroom learning activities simultaneously via computer-mediated communication technologies such as video conferencing. By following this approach, on-campus students attend F2F lessons in the physical classroom. Meanwhile, online students who are situated at multiple sites participate in the identical classroom learning activities via two-way video conferencing in real time. A typical blended synchronous learning layout is shown in Figure 1.

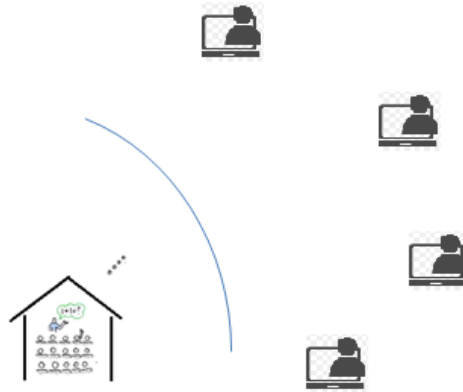


Figure 1. Blended synchronous learning layout.

Blended synchronous learning has the potential to integrate the respective strengths of blended learning (e.g., flexibility and convenience) and synchronous learning (e.g., immediate feedback and increased motivation), and reduce the limitations that blended asynchronous learning often has. Nevertheless, it has challenges as well. The following sections will elaborate on its benefits and challenges.

Benefits

The benefits of blended synchronous learning can be broadly classified into practical, educational, and economic categories (Bower Dalgarno, Kennedy, Lee, & Kenney, 2015; Chen, Ko, Kinshuk, & Lin, 2005). In terms of practical benefits, blended synchronous learning becomes increasingly affordable with the advancement of computer-mediated communication technologies. A teacher can easily set up a BSLE even without financial support (Wang & Wiesemes, 2012). Also, the BSLE can offer much flexibility and convenience to students, who have a choice to attend a lesson in the classroom or online (Stewart, Harlow, & DeBacco, 2011). In addition, blended synchronous learning also provides an alternative way to ensure the continuity of instruction when a pandemic occurs (White et al., 2010).

With regard to educational benefits, blended synchronous learning can help to establish rich teaching presence, social presence, and cognitive presence (Garrison, Anderson, & Archer, 2000; Szeto, 2015). A BSLE provides a mimic classroom environment (White et al., 2010), where teachers' direct instruction and facilitation can be easily carried out and the teaching presence is hence naturally established. Also, it enables online students to observe classroom students and the instructor and socially interact with them via two-way video conferencing, and therefore social presence is created. In addition, both classroom and online students can construct knowledge by being engaged in instructional activities and sustained communication, and more perspectives can be shared (Cunningham, 2014; Stewart, Harlow, & DeBacco, 2011). As a result, cognitive presence can be easily promoted.

Blended synchronous learning has economic benefits as well. As it depends less on the physical infrastructure (e.g., classroom), it has the potential to increase the number of enrollment and the ratio of student-teacher and reduce the cost for universities (White et al., 2010). Also, it can save students' costs related to travel and time (Chen et al., 2005; Kear et al., 2012). Moreover, it can prevent teachers from repeating the same lesson for absent students and save their time for teaching preparation and research (Cunningham, 2014).

Challenges

Nevertheless, blended synchronous learning has challenges with the teacher and students. From the teacher's perspective, the teacher is often cognitively overloaded in the process of conducting blended synchronous learning sessions as s/he needs to perform multiple roles such as a content presenter and a facilitator (Szeto, 2015), and pays attention to both classroom and online students at the same time (Bower et al., 2015). Also, the online students may post questions in text chat but the teacher is hard to read text messages in the instructional process (Bower et al., 2015). Furthermore, the teacher often has to help online students to resolve varied technical problems encountered, which requires the teacher to be technologically competent (Kear et al., 2012). In addition, some research also reports that the institutional support is often lacking and the teacher's efforts in preparing and designing online learning are not fully recognized by the institute in the promotion and tenure exercise (DeRanieri, 2012; Ocak, 2011).

From the students' perspective, online students may feel isolated or excluded from the class as they are physically separated from the class (Cunningham, 2014). Also, the online students often find difficult to communicate and collaborate with classmates or other online members (Szeto & Cheng, 2016). The online students may also feel frustrated when they encounter technical difficulties at a separate site without a nearby technician to provide immediate support (Capdeferro & Romero, 2012). In addition, the classroom students may feel neglected as the teacher may spend much time addressing the questions raised or technical problems encountered by the online students (Szeto, 2015).

A deliberated consideration is needed to balance the benefits and challenges in the developmental process of a BSLE. However, existing studies (e.g., Bower et al., 2015; Szeto & Cheng, 2016) usually describe what experiences and challenges students or instructors meet but without a detailed description of how a useful BSLE is eventually developed and improved, and what experiences are gained from the process. The purpose of this paper is to report on how a BSLE was gradually designed and developed by following the educational research approach and generate design principles for teachers to follow when they design and implement similar learning environments.

Methods

Context

This study was conducted in a graduate course at a teacher training institute of Singapore. The course had 13 sessions of three hours each and all sessions were conducted in evenings from 6pm to 9pm. A total of 24 students were enrolled to the course in the semester when this study was piloted. All the students were in-service school teachers. Their ages ranged from 25 to 45 years, and more than 80% of them were married with young children. As full-time school teachers, they had no time to attend courses in day time. Also, due to their work/family commitments or traffic congestion, they had difficulties travelling to the campus to attend courses in the evenings as well. As a pilot study, four sessions in the semester were converted into a blended synchronous learning mode to investigate if such an approach was feasible for them and could provide equivalent learning experiences for F2F and online students. Therefore, a BSLE was created using two-way video conferencing to provide a setting for the online students to attend the sessions at multiple sites (e.g., at home) simultaneously.

Each session had approximately six students to join online while the rest attending the lesson in the physical classroom. They took turns to attend the sessions online and each student attended one blended synchronous learning session on average. An online Google spreadsheet was created for the students to coordinate their participation.

Design

This study followed the educational design research approach (van den Akker, 1999) or design-based research approach (Cobb, 2001). According to Plomp (2013), educational design research has a twofold purpose: i) to produce a high-quality artifact through an iterative process; and ii) to generate design principles. In accordance with the purpose, this study aimed to develop a useful BSLE where classroom students and online students could attend the same sessions at multiple sites in real time. According to Kirschner, Strijbos, Kreijns, and Beers (2004), a useful learning environment must be pedagogically, socially, and technically sound. In addition, design principles would be generated to guide teachers who attempt to design similar learning environments. The principal investigator (PI) of this study was the instructor, who is also one of the authors. He monitored closely what happened in the BSLE when he was teaching the course. In addition, a research assistant helped to take lesson observational notes in the classroom. He did not participate in class activities, but discussed with the PI and co-PI after each session.

As shown in Figure 2, this study progressed through three stages: preliminary research, prototyping, and assessment. In the preliminary research stage, context analysis and needs analysis were carried out; a literature review on the benefits and challenges of BSLEs was conducted; and tentative guiding principles for the design of the BSLE was formed. In the prototyping stage, four rounds of prototyping were carried out. Each session went through a full round of prototyping. The four sessions were spread over the semester with one or two regular F2F sessions in between. By doing so, there was enough time for the research team to reflect on the completed session and improve the following one. Each round of prototyping focused on design, implementation, and evaluation. The design emphasized on pedagogical, social, and technical perspectives, as suggested by Kirschner et al. (2004). The implementation examined how learning activities were carried out, what roles the instructor and students played, and what experiences and challenges they met. The evaluation aimed to collect students' feedback on the design and implementation of the prototype and investigate how the prototype could be further improved. Direct observation and student feedback were used to collect qualitative data. The assessment stage aimed to examine the students' perceptions of the design and implementation of the BSLE. A survey was administered to the participants. The main research question guiding the design of the study was:

- What characteristics should a useful BSLE have for the purpose of providing equivalent learning experiences for classroom students and online students to attend identical lessons at multiple sites simultaneously?

More specifically, this research question aimed to address what pedagogical, social, and technical features the BSLE should have, and what experiences and challenges the students had in the implementation process, and how to improve the environment based on the lesson observation notes and feedback collected. The following section will report on how the BSLE was gradually improved through the four rounds of prototyping.

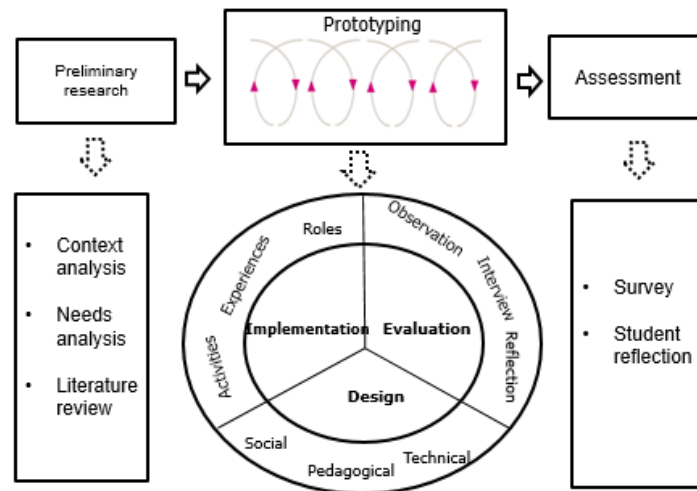


Figure 2. The educational design research process.

The Prototyping Process

Round 1

Design. The design focused on pedagogical, social, and technical perspectives. The following guiding principles generated from the preliminary research stage were applied into the pedagogical design. First, the presentation and instructional activities should remain unchanged so that the instructor did not need to modify the existing lesson design. Second, online and classroom students should have equivalent learning experiences. Third, the online students could be able to engage in the lesson via technology-mediated communication in real time. Based on these guiding principles, the instructor did not change the instructional activities, the contents, and the layout of the presentation in this round.

The social design aimed to provide a friendly environment where students and the instructor could socially project themselves, communicate and interact with each other (Wang, 2008). In order to establish mutual social presence for classroom students, the instructor, and also the online students, two-way video conferencing was adopted. To promote communication and interaction, the instructor regularly observed if the online students were following the instructional process. The online students were also encouraged to ask questions freely.

The technical design aimed to provide a usable environment so that the online students had no technical difficulties in accessing and using the environment. Each online student had a headset with a mic and a camera. The instructor had a wireless mic for easily picking up and transmitting voice to the online students. A premium version of the video conferencing tool Zoom (<http://www.zoom.us>) was used. The basic features of the tool were demonstrated to the students in the F2F lesson prior to the first blended synchronous learning session. Everyone downloaded the tool and installed it to their computers in the classroom, and the students were given about half an hour to explore the tool. Some students further installed the software into their mobile devices to explore video conferencing features. There was no critical technical problem encountered in the F2F session.

Implementation. Three students attended this session at homes while the rest were in the classroom. Every online student successfully connected to the video conferencing room before the start of the lesson. As shown in Figure 3, their streaming videos were clearly displayed on the classroom projector. The instructor shared the PowerPoint slide with the online students using the tool Zoom. Both the online and classroom students could view the slide and the streaming videos. The instructional process was video recorded in Zoom and later uploaded to the course web site for the students to review.



Figure 3. A screen capture of the instructor's computer.

Evaluation. It was observed that the online students could follow and participate in the instructional process but their engagement level was relatively low. One online student remained visible in the whole session. However, the other two online students turned off their webcams occasionally and did not respond when they were called upon. Most likely they left computers and did not concentrate on the instructional process.

The instructor had difficulties in paying full attention to the online students. He sometimes forgot the existence of the online students due to the streaming videos were displayed on the projector behind him. Also, he seldom checked for text messages in the embedded chat box during the presentation. As a result, some questions posted into the chat box remained unanswered. In addition, the videos covered an area of the slide and sometimes important information on the slide was blocked.

To further identify the experience of the online students, an email was sent to them for feedback. An online student responded that he felt a bit isolated from the class, and it was also tiring for him to stare at the computer screen for three hours. Another student expected to view the full classroom but the camera focused on the instructor only. They indicated that they could not follow the instructor to the website when he clicked on a link on a slide. The research team – the PI, co-PI, and the research assistant – discussed and reflected on the lesson observation notes and feedback collected from the students. After prioritizing the importance of identified issues, they made the following revision decisions to:

R1. Pay particular attention to the online students;

R2. Provide online students an overview of the classroom; and

R3. Adjust the layout of the PPT slide to avoid covering important information.

Round 2

Design. A new strategy of partnership was introduced into the second session for the purpose of helping the instructor to pay particular attention to the online students [R1]. Each online student was partnered with a classroom student, who helped to convey the questions or doubts from the online student to the instructor promptly (Bower et al., 2015). To help online students better observe what was happening in the classroom, an additional camera was added in the classroom [R2]. This camera was put at the back of the room so that a panoramic view could be captured. Furthermore, one more projector was installed in the classroom to display streaming videos so that the presentation slide on the primary projector would not be covered by the videos [R3]. In addition, a group activity was added into this session and each group consisted of both classroom and online students. They were supposed to discuss on a topic and give a short presentation at the end of the activity.

Implementation. Four online students joined this session and three classroom students were chosen as partners with one partner helping two online students. It was observed that the partnership strategy worked well in this session. The classroom partners and the online counterparts used the chat box or other social media tools such as WhatsApp to communicate. Several times the classroom partners conveyed the questions from the online counterparts to the instructor promptly. In addition, a few students in the classroom also joined the video conferencing room voluntarily. By doing so, they could watch the presentation slide and the streaming videos on their computers more easily. Also, the instructor could check with them what the shared screen looked like.

Unexpectedly, noise became a serious problem in this session. In particular, an online student complained that he could not hear the instructor's voice clearly as there was a strong echo inside. The instructor spent about 15 minutes trying to solve the problem but failed. In the end, the instructor had to ignore the problem and continue with instruction as the classroom students were waiting for the lesson to start.

The group members in the classroom had some difficulties communicating with the online members at the beginning of the group activity. Gradually, they managed to discuss with the online members in text. Also, it was identified that a maximum of four videos could be displayed on the projector when a computer screen was shared, and the other videos could only be shown by scrolling up or down. As a result, the presentation slide was not heavily affected by the streaming videos even though the number of videos increased.

Evaluation. An email was sent to the online participants and also the classroom partners for feedback. The online students commonly indicated that the audio quality was poor. Also, it was hard for them to find a proper time to interrupt the instructor's presentation to ask questions. In addition, it was rather inconvenient for them to participate in group discussions because the group members in the classroom had no mics. Moreover, they could not observe the movement of the laser pointer used by the instructor to highlight the content on the slide. Two online students also mentioned that their classroom partners did not keep monitoring text chat closely. As a result, they did not get immediate responses occasionally. On the other hand, a classroom partner indicated that she could not concentrate on the instructor's

presentation as she had to frequently check text chat and interact with the online partner. After the research team discussing on the lesson observation notes and students' feedback, the following revision decisions were made to:

- R1. Reduce the negative effect of the online students' participation on the classroom students;
- R2. Lower the influence of the technical problems encountered by the online students over the classroom students;
- R3. Allow online students to easily follow the content;
- R4. Enable online and F2F group members to easily discuss and collaborate; and
- R5. Improve the quality of audio transmission.

Round 3

Design. The partnership strategy remained in this session, but each classroom partner had one online counterpart only so that the local partner would not be overstressed [R1]. To avoid the class delay caused by the technical problems encountered, the online students were reminded to join the video conferencing room at least 10 minutes before the lesson started so that potential technical problems could be identified and resolved in advance [R2]. In order for the online students to easily monitor and follow the content highlighted on the projector, a wireless mouse was used to replace the remote clicker in this session [R3]. In addition, six cameras with built-in mics were prepared for group activities [R4].

It was found that the echo was caused by the built-in mic of the newly added camera. In this session, all built-in mics were turned off [R5]. In addition, a demonstration was given in the classroom to show how a printed image became interactive when it was viewed on a mobile phone.

Implementation. Eight online students attended this session online. The instructor and most online students joined the video conferencing room before the lesson started. The instructor further reminded the online students to mute their mics. The student who complained about the sound problem attended this session from home again. He was happy with the improved quality of sound. Figure 4 shows what the BSLE looked like in this session.



Figure 4. An illustration of the BSLE.

It was observed that the classroom students were excited during the demonstration, but the online students were rather quiet. It seemed the online students could not observe clearly what was happening

in the demonstration. When the students started to form groups and work on their final group assignment, two online students had difficulties in finding proper groups to join as most of the classroom students did not connect to the video conferencing room. It took some time for the instructor to allocate the two online students into proper groups. In addition, most groups used the provided cameras for the online members to observe. But they preferred using text to discuss with the online members. In addition, the wireless mouse did not work well as it needed a platform to move on, which was inconvenient for the instructor when he was walking around.

Evaluation. The online students liked the flexibility offered by the BSLE. The following quote from a student illustrates on this:

I really like the flexibility of this course. ... My daughter was down with HFMD on the day of the lesson. Even though it was not my video conferencing session, I was able to attend lesson because of the availability of such technology. Otherwise, I would have to miss the lesson for the week.

However, she also mentioned that she felt detached from the class as the classmates were enjoying the instructor's demonstration but she could not watch clearly. She felt expected to be in the classroom at that moment. Another online student mentioned that she could not hear the voice of the classmates when they asked questions. She suggested that an additional mic should be provided for the classroom students to talk into. After the research team discussing on the lesson observational notes and students' feedback, the following revision decisions were made to:

R1. Enable the instructor to more easily highlight content for online students to follow; and

R2. Improve verbal communication between the online and classroom students.

Round 4

Design. For easily highlighting contents on the projector and making annotations during the presentation, the instructor used a mobile phone to present in this session [R1]. The instructor used the Zoom app to share the phone screen with the online students. He also used the phone to turn the PPT slide and highlight key points. For easy communication between the online and classroom students, an additional wireless mic was provided for the classroom students to speak into [R2].

Implementation. Six online students attended this session. They had no difficulty in viewing the shared PPT and communicating with the instructor. Also, the instructor could easily highlight contents and make annotations on the mobile phone screen. However, SMS or email messages occasionally popped up on the screen which caused some distraction. In addition, the classroom students tended to directly talk though they were reminded to talk into the mic.

Evaluation. The online students commented that the use of a mobile phone enabled them to easily follow the instructor's presentation. It was much better than using a remote clicker or a wireless mouse. Nevertheless, they indicated that using a tablet device without email and SMS facilities might be less distracting.

The classroom students mentioned that letting them talk into a mic was unnatural. Unlike in a big auditorium, the instructor and classmates were closer to each other in the classroom, and they did not

have the habit of talking into a mic in such a setting. The research team planned to make the following revision decisions to:

- R1. Use a tablet device without email or SMS facilities to present; and
- R2. Conduct lessons in a studio-like classroom with improved sound facilities.

Appendix 1 shows an overview of the design, implementation, and evaluation activities in the prototyping stage.

Assessment

An online survey was administered to the students at the end of the course to examine their perceptions on the design and implementation of the BSLE. To ensure the validity of the instrument, the research team designed the survey questionnaire after a consultation with two experts in the field of online learning environment design. The survey consisted of twenty-three 5-point Likert scale items (1: strongly disagree; 5: strongly agree), with 11 items focusing on the pedagogical, social, and technical designs of the environment, and the rest on the perceived differences and the students' preferences. In the end, 17 students completed the survey anonymously. The mean and standard deviation scores were calculated using SPSS. Results are presented in Table 1.

Design

In terms of the pedagogical design, online students could follow and concentrate on the presentation when they took part in the blended synchronous learning sessions (#1: $M=4.00$, $SD=.866$). Also, participating in the blended learning sessions was an exciting learning experience for them and they learned how to implement a lesson in a similar way in the future (#4: $M=4.29$, $SD=.588$). In addition, the partnership strategy was perceived helpful in spite of certain limitations such as affecting the concentration of the classroom partner (#3: $M=3.35$, $SD=.702$).

Regarding the social design, the online students felt that they could communicate with the instructor (#6: $M=3.41$, $SD=.870$) and with the classmates (#7: $M=3.35$, $SD=1.115$) though they had encountered certain difficulties occasionally. They could also collaborate with the members during group activities (#9: $M=3.41$, $SD=1.228$). Encouragingly, the online students disagreed with the statement that they felt detached from the class (#10: $M=2.53$, $SD=1.007$). With respect to the technical design, it seemed the BSLE was easy to use and the students did not meet critical technical problems (#11: $M=2.24$, $SD=1.033$).

Implementation

Some differences were perceived between attending the BSLE online and in the classroom. Despite the commonly reported practical, educational, and economic benefits in literature, the survey result indicated that the BSLE should not replace the physical classroom as the former could hardly provide the same level of interactions offered by the latter (#12: $M=2.94$, $SD=1.088$). Other research shows that the BSLE might negatively affect the learning experience of the classroom students due to the fact that the instructor may spend much time troubleshooting technical problems for the online students resulting in paying less attention to the classroom students (Szeto, 2015). Gratifyingly, this was not a

critical issue in this study as the students slightly disagreed with this statement (#15: $M=2.12$, $SD=.928$). The survey also found that students felt more comfortable when they attended the lessons at homes than in the classroom (#13: $M=3.65$; $SD=0.931$); they were engaged in the lesson activities as much as in the classroom (#14: $M=3.24$; $SD=0.903$); and they believed that taking blended synchronous learning via video conferencing gave them equivalent learning experiences (#16: $M=3.59$; $SD=.939$).

The students also had a strong preference for taking blended synchronous learning online. They expected to have more blended synchronous learning sessions in the course (#19: $M=3.71$; $SD=1.033$) and would like to attend the sessions from homes (#18: $M=3.76$; $SD=.939$). Also, they hoped more courses to be conducted in this approach (#20: $M=4.00$; $SD=1.033$), and intended to conduct courses in a similar way in the future (#21: $M=4.12$; $SD=.6$). In general, they were satisfied with the implementation process (#23: $M=4.18$, $SD=.728$).

Table 1

Descriptive Statistics (N=17)

	M	SD
Pedagogical design		
1. I could concentrate on the instructor's presentation when I was online	4.00	.866
2. I could easily observe what was happening in the classroom via the webcams	3.41	.939
3. The partnership strategy was helpful for me to follow classroom instruction	3.35	.702
4. I learned how to implement a lesson in a similar way from the course	4.29	.588
5. Participating in the blended lessons was a useful learning experience to me	4.53	.514
Social design		
6. I could easily communicate with the instructor during the 3h lesson when I was online	3.41	.870
7. I could easily communicate with the classmates via audio/video	3.35	1.115
8. As an online participant, I frequently used text chat to communicate with the classroom participants during the lesson	3.71	1.213
9. I could collaborate with my group members when I was online	3.41	1.228
10. I felt isolated when I joined the lesson at a remote site	2.53	1.007
Technical design		
11. I met critical technical problems/difficulties when I joined the F2F lesson at a remote site (e.g., at home) via video conferencing	2.24	1.033
Difference		
12. Attending the lesson online via video conferencing gave me similar feeling to attending other lessons in the classroom	2.94	1.088
13. I felt more comfortable when I attended the lesson at home than in the classroom	3.65	.931
14. I was engaged in the lesson activities as much as in the classroom	3.24	.903
15. As a classroom participant, I felt that having remote participation negatively affected my learning experiences	2.12	.928

16. I believe blended learning can have equal or even better learning experiences than classroom learning	3.59	.939
Preference		
17. I prefer attending a lesson via video conferencing to attending it in the classroom	3.41	1.004
18. I would choose video conferencing if I am given this option in a course	3.76	1.033
19. More sessions in this course could be conducted in this blended way	3.71	.985
20. I will be willing to take more courses conducted in such a blended way in the future	4.00	1.033
21. I would conduct lessons in a similar way in the future if possible (e.g., during Haze)	4.12	.600
22. I like the blended synchronous learning approach adopted in this course	3.94	.966
23. Overall, I am satisfied with the sessions conducted in the blended synchronous way	4.18	.728

Discussion

The main purpose of the study was to describe how a useful BSLE was eventually developed by following the educational design research approach and identify students' experiences and perceptions of the design and implementation of the environment. In this section, key findings from the study are to be discussed and design principles for guiding the development of similar learning environments are generated.

Benefits and Challenges

This study supports the notion that blended synchronous learning has the capacity to provide a meaningful opportunity for the students who cannot come to the campus to attend classroom instruction via two-way video conferencing in real time. In this study, the BSLE offered a convenient and flexible setting where the online students could attend lessons at homes by using any device. Furthermore, it provided the online students equivalent learning experiences to studying in the classroom. These findings are consistent with the reported practical, educational, and logistic benefits reported in literature such as Bower et al. (2015) and Chen et al. (2005). Nevertheless, this study also identified some additional challenges.

Challenges for the instructor. In addition to the often reported challenges with instructors such as cognitive overload, high technological competency, and a lack of institutional support (Bower et al., 2015; Kear, et al., 2012; Szeto & Cheng, 2014), effectively balancing attention paid to the online students and classroom students seems to be a striking challenge. In this study, the instructor would forget the existence of the online students in the instructional process and therefore had to intentionally remind himself. On the other hand, spending much time checking with the online students or solving their technical problems caused a waste of significant time for the classroom students and resulted in students feeling neglected as identified by Szeto (2015). Another challenge is that the instructor had to adapt to this new environment, for instance, by getting used to talking to the camera or using a mobile device to present.

Challenges for online students. This study reveals that the communication between online students and classroom students, and between the online students and the instructor is a challenge. Unlike in the classroom, where facial expressions and body language are more visible, the online students in the BSLE had a difficult time asking questions and getting the instructor's attention. Also, their classroom partners might not check text chat as frequently as required to deliver their questions to the instructor. In addition, it was hard for them to observe certain classroom events such as demonstrations.

Challenges for classroom students. This study also shows that the participation of online students may affect the engagement of classroom students as well. This finding is consistent with what Szeto (2015) identified but with different reasons. In this study, some classroom students mentioned that being partners with online students made them lose concentration on the instructor's presentation. Also, they found it was not natural and smooth to communicate and collaborate with online members during group work. The classroom students had to adapt to the new environment; they identified that the participation of the online students affected their concentration and engagement more than if they did not have to include this new element in the classroom.

Design Principles

According to van den Akker (1999), design principles can be better presented in a form of heuristic statements like

If you want to design curriculum X [for the purpose/function Y in context Z], then you are best advised to give that curriculum the characteristics A, B, and C [substantive emphasis], and to do that via procedures K, L, and M [procedural emphasis], because of theoretical and empirical arguments P, Q, and R (p. 9).

By following this format, the design principles summarized from this study are presented as the following: If you want to design a useful BSLE for the purpose of delivering instruction to both classroom students and online students via video conferencing simultaneously, you are best advised to incorporate the following characteristics into the learning environment:

- a. Certain activities (e.g., demonstrations, group discussions) must be redesigned for online students to easily participate in;
- b. The partnership strategy can be incorporated in the learning environment to facilitate the communication between online students and the instructor;
- c. The instructor must pay a balanced attention to the online and classroom students;
- d. Clear video communication must be ensured, and the online students preferably use voice only to communicate with the instructor as it is hard for the instructor to read text in the instructional process;
- e. The learning environment must be easy to use and the students must be trained in advance to reduce possible technical difficulties;

- f. The classroom should have at least two cameras and two mics with one camera focusing on the instructor and the other capturing the whole classroom. Similarly, one mic is for the instructor, and the other is for the classroom students to talk into.

Future Research

Future research would further explore how to better blend the classroom and the virtual environment. The online students could watch what the cameras captured, but did not share the same 3D space (Anastasiades et al., 2010). The instructor and classroom students could also only observe what the streaming videos showed on the screen. The experience of observing streaming videos is different from involving in an authentic environment. How to better integrate a virtual learning environment into the classroom environment to provide online students with a more authentic classroom-like setting, for instance, by creating a 3D immersive learning environment using virtual reality (VR) technologies, should be further explored in future studies.

In addition, it would be beneficial to examine how to increase the engagement level of the online students. Sometimes the online students felt bored and walked away from their computers during the instructional process. How to better involve them in the instructional process needs to be further researched. In addition, how to monitor their participation and engagement should also be studied as their presence in the streaming videos does not mean they are following or engaged in the instructional process. Moreover, a proper class size for blended synchronous learning could be further explored. Theoretically, the class size of a BSLE can be infinite. However, the results of this study indicated that the instructor and students faced varied challenges. Undoubtedly, additional challenges would emerge when the class size increased. Future research would further explore an optimal class size for a BSLE.

Conclusion

The purpose of the study was to create a useful BSLE for online students to participate in classroom instruction via video conferencing in real time by following the educational design research approach. Through four rounds of prototyping, the learning environment was gradually designed, implemented, and improved. The results of the study showed that the BSLE had the capability to provide equivalent learning experiences for the online students and classroom students, but it had certain challenges as well, and the instructor and students had to deliberately address the challenges and adapt to the new learning environment to make the instructional process more meaningful. Design principles were summarized for researchers and instructors to follow when they are designing similar learning environments.

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Corresponding author: Dr. Xiaoyong Hu, huxiaoy@m.scnu.edu.cn

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Appendix 1

An Overview of the Prototyping Process

	Round 1	Round 2	Round 3	Round 4
DESIGN	<ul style="list-style-type: none"> The instructor used the traditional way to conduct the session The instructor encouraged online students to actively participate A paid version of Zoom was used One camera and one mobile wireless mic were used 	<ul style="list-style-type: none"> The instructor checked and monitored the online students The instructor attempted to engage the online students The instructor paid equal attention to online and F2F students The partnership strategy was applied The session involved a group activity Two cameras and two projectors were used 	<ul style="list-style-type: none"> The instructor and online students joined the conferencing room earlier Group activities involved both online and F2F students The partnership strategy was remained Cameras would be provided for the group activity 	<ul style="list-style-type: none"> The instructor used a mobile phone to present A mobile wireless mic was provided
IMPLEMENTATION	<ul style="list-style-type: none"> Three students attended online The instructor shared the PPT The instructor used the remote clicker to turn slides The instructor regularly checked and monitored the online students The online students used headsets with cameras and mics All the mics of the online students were muted by default 	<ul style="list-style-type: none"> There were four online students and three classroom partners The instructor shared the screen The lesson was delayed for 15 minutes Each group had an online student and three classroom students 	<ul style="list-style-type: none"> Six cameras with mics were prepared Eight students attended online A class demonstration was conducted A camera was provided for each group A wireless mouse was used to replace the clicker The instructor arrived at the classroom 15 minutes before the lesson started 	<ul style="list-style-type: none"> The mobile phone enabled to highlight and annotate
EVALUATION	<ul style="list-style-type: none"> The level of engagement was low It was hard for the instructor to pay attention to the online students The instructor seldom checked text chat 	<ul style="list-style-type: none"> Noise was a serious problem The online students could not observe the movement of the red point of the clicker 	<ul style="list-style-type: none"> The sound was clear the online students could not see the class demonstration clearly 	<ul style="list-style-type: none"> Using a mobile phone to present worked well. But using a tablet might be better

	<ul style="list-style-type: none"> • Part of the slide was covered by the videos • The online students could respond to the questions • The online students could not hear the voice of the classmates clearly • The online students felt isolated • It would be better to share the full screen rather than the PPT only • How to balance the PPT layout and the videos so that the PPT would not be covered? • How to better capture video from the classroom? • How to pay particular attention to the online students? 	<ul style="list-style-type: none"> • The partnership strategy worked well, but may negatively affect the attention of the classroom partner • The online and F2F students had difficulties in communication at the beginning of the group activity • The tool could display 4 videos only • A few classroom students joined the conference room voluntarily • It was hard for the online students to find an appropriate time to ask questions • How to improve the quality of audio? • How to minimize the negative effect of the online participation on the classroom students? • How to draw the attention of the online students? • How to facilitate group collaboration? 	<ul style="list-style-type: none"> • Group members used text chat only to communicate • Wireless mouse did not work well • How to improve verbal communication between the online and F2F students? • How to better present the instructional content? 	<ul style="list-style-type: none"> • The classroom students did not talk to the mic
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