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A systematic literature review on synchronous hybrid learning: gaps identified

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Abstract
More and more higher educational institutions invest in technology-enhanced learning spaces, which raises the question of how these environments can be shaped to be as effective as possible. A specific new learning space is the synchronous hybrid or blended learning environment in which both on-site and remote students can simultaneously attend learning activities. Given that synchronous hybrid learning is relatively new, there are few studies that have investigated its use and effectiveness. This study synthesised the best available evidence worldwide to provide an overview of the state-of-the-art of the current research regarding the benefits, challenges and current design principles to set up synchronous hybrid learning. In line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, we included 47 studies which were analysed to respond to our research questions. One of the main findings is that existing research suggests cautious optimism about synchronous hybrid learning which creates a more flexible, engaging learning environment compared to fully online or fully on-site instruction. Yet, this new learning space has several challenges which are both pedagogical and technological in nature. To meet these challenges, several design guidelines are formulated. A final conclusion is that most of the existing literature is exploratory and qualitative in nature and has focused mostly on descriptions of students' experiences, the organisational implementation and the technological design. Empirical studies have only begun to emerge and more research is needed into different pedagogical scenarios and their impact on student outcomes.

Keywords Here or there instruction · Research gaps · Synchronous hybrid or blended learning · Systematic review

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Introduction

Based on current societal transitions and in the context of the EU Lifelong Learning Program, both higher education and adult learning institutions are invited to constantly think about how to enable people, at any stage of their lives, to take part in stimulating learning experiences. Regarding higher-education settings, current policy documents often refer to the possibilities of multi-campus learning and inter-institutional collaboration by connecting remote groups with the traditional face–to–face classrooms (see for example the 'Going Digital strategic plan of KU Leuven: https://www.kuleuven.be/english/about-kuleuven/strategic-plan/going-digital). Furthermore, the need for connecting remote individual students is increasing as the population in higher and adult education is getting more diverse. 'Lifelong learners' often cannot attend traditional classroom instruction because of, for example, family or work commitments. Within this context, digital technologies are often proposed as a possible answer to change the educational landscapes and make it more flexible and accessible for a larger group of learners (Cain 2015). As access to synchronous communication tools improves, the lines between traditional face–to–face and online models of education (e.g. MOOCs) have become blurred, making way for new synchronous hybrid or blended approaches (Alexander et al. 2014; Roseth et al. 2013). Previous studies show that different models of synchromodal classes can be designed and implemented (Bell et al. 2014; Bower et al. 2014, 2015).

Recently, at the university KU Leuven Campus Kulak Kortrijk, two models of synchronous hybrid learning environments were designed as displayed in Fig. 1.

The picture on the left in Fig. 1 depicts what we call the Remote Classroom, whereas the picture on the right depicts the Hybrid Virtual Classroom. Both learning settings have in common that both on-site or 'here' students and remote or 'there' students are simultaneously included. This kind of learning and instruction is also framed as Here or There (HOT) instruction (Zydney et al. 2019). The difference between the Remote and the Hybrid Virtual Classroom involves the location where students follow the lecture. In the Remote Classroom setting, one group follows the course on campus and another group follows the course synchronously from another campus (the remote location and students are displayed on the screen depicted in the left corner of Fig. 1) (Szeto and Cheng 2016). In the Hybrid Virtual Classroom, one group follows the course on campus and simultaneously individuals follow the course remotely from the location of their choice (Butz et al. 2016; Hastie et al. 2010). This method of teaching offers even more flexibility because it gives adult students, as well as students who are, for example, abroad or ill for a longer period of time,

The Remote Classroom **The Hybrid Virtual Classroom**

Fig. 1 Two models of synchronous hybrid learning at Edulab, the living lab of KU Leuven Campus Kulak Kortrijk

the opportunity to participate in the actual lesson and interact at a distance with all students and the teacher from a place of their own choice.

These learning environments have been constructed in collaboration with our industry partners in the context of the TECOL project (https://www.kuleuven-kulak.be/tecol?lang=en) and the imec.icon project LECTURE+project (see Acknowledgements for more info). The newly-designed learning spaces function as living laboratories for studying new modes of teaching and learning. The two settings are equipped with innovative educational technology and all students have access to the same interactive platform shown in Fig. 2, allowing them to participate in the course, either on-site or from a remote location. The platform gives access to the sources that teachers are using during lectures (e.g. Power point slides or annotations made on the digital whiteboard), quizzes or polls and a chat room which enables students to chat with each other or with the teacher during the lecture. Lectures in the Hybrid Virtual Classroom are mostly assisted by a room controller who follows up on the chat, can launch the quiz or poll and can mute or unmute remote students.

Research objective

At the start of the research project on synchronous hybrid learning, we aimed to conduct a systematic review to learn from earlier studies and to prevent both researchers and practitioners from making the same mistakes. As stated earlier, without a systematic review, a new trial might add little to what is already known in the field (Baumeister and Leary 1997; Bettany-Saltikov 2010a, b).

We aimed to summarise existing evidence concerning synchronous hybrid learning with regard to the benefits, challenges and current design guidelines. Based on this state-of-the-art, we further aimed to identify existing gaps in current research in order to suggest areas for further investigation.

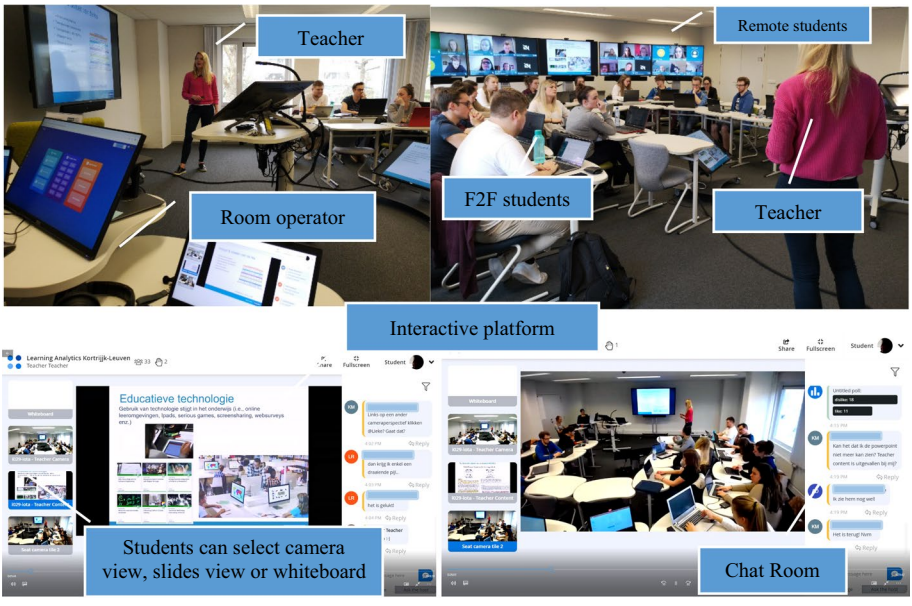

Fig. 2 Hybrid virtual classroom including both F2F and remote individual students (upper pictures) and the platform visible for the students (lower pictures)

The following review questions were delineated:

1. What is the state-of-the-art in research on synchronous hybrid learning?
2. What are the main benefits of synchronous hybrid learning?
3. What are the main challenges of synchronous hybrid learning settings?
4. What are the current design guidelines to optimise synchronous hybrid learning?

In what follows, first, we outline in detail the methodology used in the systematic review. Second, results for the four research questions are presented. Finally, the main conclusions of the review are discussed and implications for future research, policy and practice are provided.

Methodology

Inclusion and exclusion criteria

As the setting under review was relatively new and one of the objectives was to find commonalities and gaps in research, the review considered studies that explored any aspect of synchronous hybrid learning and teaching. We predefined neither the population nor the topic of interest upon which the study should focus on. Nor did predefine criteria related to the method of the study because we were especially interested in the kind of studies that already have been conducted. This means that a variety of quantitative and qualitative study designs were considered for inclusion. Also this review considered studies that explored any learner outcome (i.e. cognitive and affective outcomes) as long as it was within the context of a synchronous hybrid or blended learning environment in the form of a remote classroom or a hybrid virtual classroom as described above. This means that this review excluded literature focusing only pure virtual classrooms including remote students without on-site students.

Search strategy

A specific search strategy was followed to find both literature published in peer-reviewed journals and 'grey' literature (such as conference proceedings). This included a search of electronic databases and a manual search of the reference lists of all the identified relevant articles using the snowballing method. We systematically searched the following electronic databases: Web of Science, ERIC, Scopus and LearnTechLib. Keyword descriptors for publications on synchronous hybrid learning and teaching comprised the following groups of search terms: (a) simultaneous, synchronous; (b) hybrid, hyflex, blended; and (c) face–to–face, face to face; (d) education, teaching, learning. Search terms within each group were combined by means of a Boolean OR. The four groups of search terms were combined by means of a Boolean AND. In addition, to exclude studies on asynchronous learning, this term was entered by means of Boolean NOT. Depending on the options of the different databases, the results were further refined by the filters 'Education—educational research', 'Social Sciences', 'Peer reviewed only' and 'Education scientific disciplines'. This resulted in the following full search query:

$TS = (simultaneous\ OR\ synchronous)\ AND\ TS = (hyflex\ OR\ hybrid\ OR\ blended)$
$AND\ TS = (face - to - face\ OR\ face\ to\ face)\ AND\ TS = (education\ OR\ teaching\ OR\ learning)$
$NOT\ TS = (asynchronous)$

Articles deemed relevant were retrieved for full-text review and were assessed for inclusion using the pre-established selection criteria. Studies were limited to the English language. There were no date limitations placed on the review.

This research involves no human participants, but includes pictures from a research project which has been reviewed and approved by the Social and Societal Ethics Committee. Informed consents were obtained from all individual participants which are visible on the pictures.

Data analysis

In order to obtain a systematic review of good quality, the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) were used. These guidelines consist of a checklist and a flow diagram, and help to improve the reporting of the review. A summary of the search and selection process is presented in Fig. 3 and is based on the PRISMA statement (Moher et al. 2009). The Boolean search query in the four databases resulted in 286 studies, but 92 were duplicates. This resulted in 194 studies which were screened based on title and abstract. This identification and screening phase was completed by the first two authors independently from each other. It was checked in more detail to ascertain whether the study involved a synchronous hybrid learning setting because, in many cases, this was not clear from the abstract. Then, these studies were selected for full text screening. In total, 72 manuscripts remained for further assessment through reading the full text, which was undertaken by the first two authors. The results were discussed in weekly face–to–face meetings. Doubtful case were also screened by the third author. Many studies were removed ($n = 36$) because they did not meet the selection criteria. The most common reason for exclusion was that the research did not involve synchronous learning

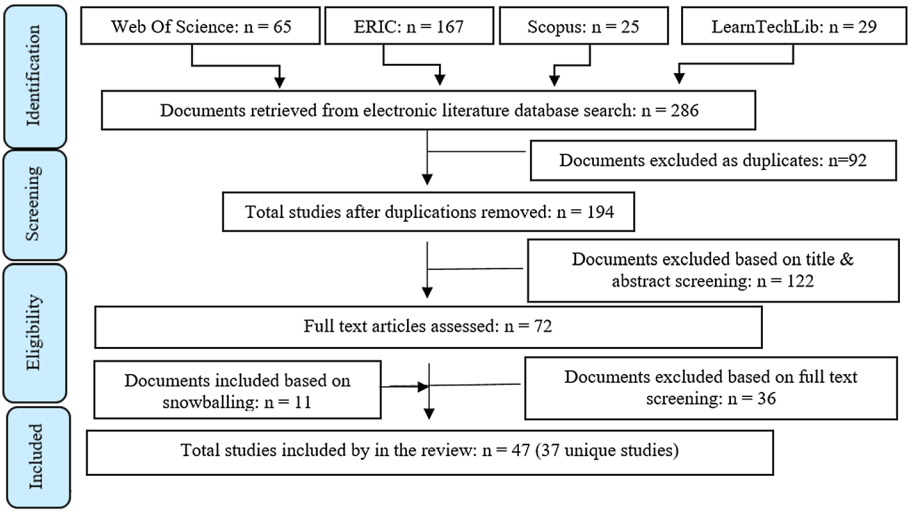

Fig. 3 Overview of the search conducted in May 2019 based on PRISMA statement

situations as defined above. For example, any study reporting a blended course that integrated Synchronous Online Discussion and Face–to–Face Instruction separately, but not combining this at the same time, was removed (e.g. Blau et al. 2018) as was any study about synchronous learning in a pure virtual class without on-site participants (e.g. Baker and Hjarlmarson 2019). Based on the references lists of the remaining studies, 11 additional studies were found. This resulted in 47 studies which were analysed to answer the four research questions (see Table 1). In seven cases, studies were clustered because the publications involved the same learning setting and/or set of participants.

Results

State-of-the-art of research on synchronous hybrid learning

To answer Research Question 1, aimed at insight into the SOTA, each publication was analysed with regard to (a) the study design and research methodology, (b) the study purpose, (c) the learning setting (Is the synchronous hybrid learning environment shaped as a Remote Classroom connecting groups or as a Hybrid Virtual Classroom connecting on-site participants with remote individuals?) and (d) the context of the study and the number of participants. Table 1 summarises the results of this analysis.

The first study on synchronous hybrid learning which was found dates from 2003 and was a qualitative case study aimed at observing the quantity and quality of human interaction between the instructor, the on-site students, and the distant students in a blended learning course. Also the work of Beatty (2007a, b) was pioneering in the development and evaluation of the HyFlex course design model for blended learning environments. Yet, most studies date from a later period between 2013 and 2019. Most of the studies were case studies (28 in total), with 15 of them using mixed-methods and 13 of them using only qualitative analysis. Next, one review study and two conceptual studies were identified. Empirical studies were limited. Only five studies took a comparative approach to study the effectiveness of different modes of delivery. Only one experimental study was found. This study involved a pretest–posttest experimental design with random assignment using a convergent parallel mixed-methods approach (Butz and Stupnisky 2017). With regard to the learning setting, it was found that the majority of the studies (29) investigated the hybrid virtual classroom. Only five studies reported exclusively on the remote classroom, while three studies tackled both the remote and the hybrid virtual classroom. Lastly, regarding the context of the study, almost all studies were conducted in the context of higher- or adult-education settings. Only one paper focused on the pedagogical utilisation of remote classrooms in contemporary elementary schools (i.e. Anastasiades et al. 2010).

Benefits of synchronous hybrid learning

Below we summarise the benefits that are indicated in previous research. Based on textual data analysis, first, the research papers were explored inductively to generate categories of recurring benefits. The inductive process of identifying analytical categories as they emerge from the data is based on grounded theory (Glaser and Strauss 1967). The data were read and reread to identify and index the benefits found. Through this process, benefits could be categorised into two categories, namely (1) organisational benefits related to

Table 1 Overview of studies included based on systematic search (in alphabetical order of author)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
1.	Abdelmalak and Parra (2016)	Hybrid virtual classroom *N* = 6 graduate students	Qualitative case study	Exploration of students' perspectives regarding the HyFlex course design
2.	Alexander et al. (2014)	Hybrid virtual classroom *N* = 171 university students	Mixed-methods case study	Snapshot of the hybrid learning environment at Bentley University that can be used as a model by those in the planning stages or early formation stages of a hybrid online course or program, and evaluation of students' experiences
3.	Anastasiades et al. (2010)	Remote classroom Context: K12 education—grade 6 *N* = 45 students and 4 teachers from 2 schools	Mixed-methods case study	Presentation of design, implementation and evaluation of the methodology which focuses on the pedagogical utilisation of Interactive Videoconferencing (IVC) in contemporary elementary schools
4	Beatty (2007a, b)	Hybrid virtual classroom Context: graduate program in Instructional Technologies at San Francisco State University *N* = 34 students	Mixed-methods case study	Description of the HyFlex course and evaluation of students' participation and satisfaction
5.	Bell, Sawaya and Cain (2014)	Remote classroom & hybrid virtual classroom Context: Hybrid PhD program *N* not specified	Mixed-method case study	Description of different models of synchromodal classes designed and implemented
6.	Bower et al. (2014, 2015), Bower et al. (2017)	Remote classroom & hybrid virtual classroom Context: higher education including 7 design cases	Cross-case qualitative analysis study	How design and implementation factors influence student learning activity and perceived learning outcomes within a blended synchronous learning design framework
7.	Brumfield et al. (2017)	Remote classroom Context: adult education	Qualitative case study	Description of the concept and design of the course

Table 1 (continued)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
8.	Butz and Askim-Lovseth (2015)	Hybrid virtual classroom Context: higher education *N* = 202 graduate students, 120 on-campus and 82 online	Exploratory quantitative study comparing different student groups: online versus on-campus, and domestic vs. international	Relationships among attendance mode, student nationality and oral communication assessment scores in a synchronous hybrid program
9.	Butz and Stupnisky (2016, 2017)	Hybrid virtual classroom Context: higher education *N* = 83 graduate students, 26 on-campus and 57 online	Pretest–posttest experimental design with random assignment to either experimental or control group, using a convergent parallel mixed-methods approach	Implementation and evaluation of an online discussion board intervention designed to scaffold feelings of relatedness and self-efficacy in synchronous hybrid learning
10.	Butz et al. (2016)	Hybrid virtual classroom Context: higher education *N* Time1 = 118 students, 48 on-campus and 70 online *N* Time2 = 100 students, 37 on-campus and 63 online	Exploratory quantitative study comparing online versus on-campus students using longitudinal analyses	Students' self-reported enjoyment, anxiety and boredom as predictors of their program achievement and successful technology use
11.	Cain (2015)	Hybrid virtual classroom Context: higher education *N* not specified	Qualitative case study	How instructors and support staff were involved in the hybrid program and explanation of their innovative solution (i.e. the role of an in-class technology navigator)
12.	Cain et al. (2016)	Hybrid virtual classroom Context: PhD program *N* = 12 doctoral students (11 remote, 1 on-site), 1 instructor, 1 teaching assistant (TA) and 1 TechNavigator	Qualitative case study with focus on the design and use of the specific application	Evaluation of the robotic telepresence devices to bring greater individualisation to online students in one particular synchronous hybrid course
13.	Cunningham (2014)	Hybrid virtual classroom Context: postgraduate education *N* = 4 students followed during real-time online participation	Qualitative case study	Evaluation of experiences of both online and campus students in light of social presence and activity theory

Table 1 (continued)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
14.	Grant and Cheon (2007)	Hybrid virtual classroom Context: higher education $N=18$, one group used video conferencing exclusively ($n=11$), and the other group used only audio conferencing ($n=8$).	Mixed-method effectiveness study comparing video and audio conferencing in hybrid classes	How synchronous conferencing technology affects teaching and learning and factors bearing on success and failure of synchronous conferencing in hybrid classes
15.	Hastie et al. (2010)	Hybrid virtual classroom Context: international collaboration between two educators involving two institutions from two countries in the Asia–Pacific region	Description of 9 design modes and empirical case study Data collected over 5-year period	Description of nine modes of synchronous hybrid learning and investigation of the educational and social gains
16.	Huang et al. (2017)	Hybrid virtual classroom Context: five teachers and students from two senior schools in China (*N* not specified)	Mixed-methods case study	(1) How the teachers' activities impact teaching effect in their courses. (2) High school students expectations of their video-enhanced teachers. (3) Actions remote students take to achieve good learning experience
17.	Lakhal et al. (2017)	Hybrid virtual classroom Context: Higher education	Review study	Description of advantages, challenges, conditions of success and formulation of a blended session protocol
18.	Lightner and Lightner-Laws (2016)	Remote classroom Context: higher education Analysis of data collected from all courses offered from fall 2009 to fall 2011	Empirical study comparing course delivery modes: online, remote and traditional and its impact on students grades Timeframe of 3 years 112,973 grades issued across 6316 courses	Impact of the environment on student performance

Table 1 (continued)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
19.	Liu et al. (2018)	Hybrid virtual classroom Context: four universities taking turns in designing, developing and delivering courses in computational science and engineering	Case study from a developmental approach	Project focusing on computer technologies as enabler for course development, student projects for model-based learning, and course delivery across different locations
20.	McGovern and Barnes (2009)	Hybrid virtual classroom Context: postgraduate degree program in advanced clinical pediatrics $N=16$ students	Mixed-methods case study	Why students choose to participate virtually and the impact of the virtual classroom on learning and communication
21.	Nortvig (2013)	Hybrid virtual classroom Context: professional Bachelor program in physiotherapy in Denmark	Conceptual study focusing on technological design	Investigation and description of how technology can affect teaching in the synchronous hybrid classroom Explaining embodiment of technology, technological transformation and influence of technology
22.	Olt (2018)	Hybrid virtual classroom $N=9$ remote students	Qualitative case study using phenomenological methodology	Phenomenon of using synchronous online classes blended with a face-to-face classroom from perspective of remote participant. Bridge to Campus initiative for providing entire freshman year of college with synchronous online coursework
23.	Ørngreen et al. (2015)	Hybrid virtual classroom Context: Bachelor Program in biomedical laboratory analysis in Aarhus	Qualitative case study as a participatory action research project	Potential and barriers from an ICT-supported learning perspective, develop robust educational designs and teaching scenarios, and train teaching staff in teaching activities which involve use of the blended class model
24.	Ramsey et al. (2016)	Hybrid virtual classroom Context: Public university $N=19$	Mixed-methods case study	Preliminary reflections on their initial experiences and present survey data regarding students' experiences

Table 1 (continued)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
25.	Rasmussen (2003)	Hybrid virtual classroom $N=6$ remote students living in various parts of the western US + 11 face-to-face students on campus	Qualitative case study	Quantity and quality of human interaction between instructor, face-to-face students, and the distant students in a blended learning course
26.	Romero-Hall and Vicentini (2017)	Hybrid virtual classroom Context: graduate level $N=3$ graduate students	Qualitative case study	Inform the design of hybrid synchronous instruction and understand effectiveness and efficiency of hybrid synchronous instruction from perspective of distance learners
27.	Roseth et al. (2013)	Hybrid virtual classroom Context: Hybrid Doctoral Seminar	Conceptual study	Rationale behind pedagogical choices and specification of various technologies to create a virtual classroom
28.	Shen et al. (2008)	Remote classroom $N=1000$ students, 250 on campus and 750 online	Mixed-methods case study	Technical description of the self-developed interactive learning system and evaluation of students' experiences
29.	Stewart et al. (2011)	Hybrid virtual classroom $N=46$ graduate students were enrolled in different courses held over the two year project	Mixed-methods ethnographic study	Experiences of learners participating in multi-site education classes
30.	Szeto and Cheng (2016), Szeto (2014, 2015)	Remote classroom Context: computer-aided engineering drawing course $N=28$ students, 14 face-to-face, 14 as remote group	Qualitative case study	Impact of the environment on students' social presence experience
31.	Vu and Fadde (2013)	Hybrid virtual classroom Context: Two sections of a graduate level multimedia design course. Semester 1: $N=15$ Semester 2: $N=13$	Mixed-methods case study	(1) Students' choices of verbal and text interaction (2) students' preference for online or remote participation

Table 1 (continued)

No.	Study	Learning setting, context & participants	Study design & methods	Study purpose
32.	Wang et al. (2017), Wang et al. (2018), Wang and Huang (2018)	Hybrid virtual classroom $N=24$ graduate students (inservice school teachers) during 13 sessions of 3 h	Design-based research (preliminary research, prototyping and assessment)	Description of benefits, challenges & providing pedagogical, social and technical design principles of a blended synchronous learning environment
33.	Weitze (2015), Weitze et al. (2013)	Hybrid virtual classroom Context: adult learning 2 classes included $N=10+N=26$	Mixed-methods case study with focus on design perspective	Students' experiences, organisational implementation and development of instructional design, the IT-Pedagogical Think Tank for Teacher Teams
34.	Whiteet al. (2010)	Hybrid virtual classroom Context: higher education $N=10$ participants	Mixed-methods case study	Feasibility of delivering a course on-campus and in real time, and simultaneously transmitting it to students remotely accessing the same course
35.	Wiles and Ball (2013)	Hybrid virtual classroom Context: Undergraduate students, 3707 enrollments over 7 semesters	Longitudinal mixed-methods case study	Design of converged classroom and presenting benefits and challenges
36.	Yen and Abdous (2012)	Combination of Hybrid virtual and remote classroom $N=496$ university students	Empirical study	Relationships between self-perceived learner–to–teacher interaction and learning outcomes and satisfaction across various learning delivery modes (F2F, Satellite broadcast or live video-streaming)
37.	Zydney et al. (2019), McKimmy and Schmidt (2014, 2015)	Hybrid virtual classroom Context: three different cases at two universities	Multiple case study focusing on design and technical issues	Different implementations of 'Here or There instruction', explanation of affordances of these varied approaches, and provision of best practices

educational access and efficiency in teaching; and (2) pedagogical benefits related to quality of learning.

Organizational benefits

Some higher educational institutions are dealing with a decline in student enrollment numbers because of the increased offering of distance and online education. The synchronous hybrid learning environment could provide an answer to this problem and help to increase recruitment rates. By offering the possibility to attend face-to-face or remotely, institutions can reach out to a greater base of potential students (Abdelmalak and Parra 2016; Butz and Askim-Lovseth 2015; Ørngreen et al. 2015; Wang et al. 2017; Wiles and Ball 2013). The hybrid virtual setting more specifically can ensure access to education regardless of place, thus providing more-inclusive education and equality in learning outcomes (Bower et al. 2015; Weitze et al. 2013). Moreover, it is possible to offer more elective or specific courses which are normally taught at one specific location, consult external experts more easily, and address the personal interests of the students and learners better (Bell et al. 2014; McGovern and Barnes 2009). Another organisational benefit is that the hybrid virtual classroom eliminates the need to teach the same course twice to different classes at different campuses, which reduces workloads (Bell et al. 2014; Brumfield et al. 2017; Wiles and Ball 2013). In addition, teachers and students do not have to move to the campus and consequently can enjoy the freedom and flexibility that this learning environment offers (Beatty 2007a, b). Hence, one of the most cited benefits is flexibility in course attendance for the students. For example, when a student is ill or when cannot move to the campus where the teacher is present, there is the opportunity to follow remotely through online participation. This kind of flexibility is more in line with the current society in which we are living (Lakhal et al. 2017; Wang et al. 2017; Wiles and Ball 2013). In addition, these learning environments accommodate job and family commitments and thus take a multifaceted student population into account (Lightner and Lightner-Laws 2016; Wiles and Ball 2013).

Pedagogical benefits

Next to organisational benefits, the hybrid virtual classroom offers the possibility to include expertise outside the institution so that students are exposed to a broader range of views and ideas, because this collaboration and connection between face-to-face and remote students creates richer learning experiences (Bell et al. 2014; Bower et al. 2015). Anastasiades et al. (2010) more specifically stressed that this setting can strengthen the social relations among students and teachers of the local and the remote class, and strengthen students' willingness to make new contacts all over the world. Also Liu et al. (2018) stressed the social benefit to students by providing equal learning opportunities to under-represented students. Likewise, the synchronous hybrid learning environment can guarantee continuity of instruction and promotes student retention (Lakhal et al. 2017; Ramsey et al. 2016; Wang et al. 2017; Wiles and Ball 2013). Weitze et al. (2013) also mention this in their study:

> The students' own choice of environment helps them manage their family and everyday life by not always having to be present at school. Several students are also pleased with being able to vary their classroom environment during a day by changing geographical location, and when sitting at home they have the feeling that the school day ended sooner. The format also creates a new 'intermediate solution' for some, when they feel 'sluggish' and normally would have taken a sick-day. In this

way, the concept contributes to their ability to complete their education. (Weitz et al. 2013, p. 5)

Synchronous hybrid teaching offers the possibility to maintain the guidance and comfort of traditional courses for both remote students and those attending face-to-face. Moreover, by combining the two delivery modes, there is better support of the different learner characteristics and students can benefit from enhanced instruction and well-timed interactions (Szeto 2014; Wiles and Ball 2013). Abdelmalak and Parra (2016) moreover state that synchronous hybrid learning gives students a better sense of control over their learning.

Lastly, by teaching this way, students also encounter the many possibilities that technology has to offer and they learn how to work with it. This can prepare them for careers in our technology-rich society (Butz and Askim-Lovseth 2015; Ørngreen et al. 2015).

Only limited studies have involved empirical research to assess differences in outcomes between students who attend online versus in-person, yet the existing studies (Lightner and Lightner-Laws 2016; Szeto 2014; White et al. 2010) provide evidence for the notion that flexible course delivery options have little to no negative impact on student learning because it results in similar learning outcomes, such as test scores (White et al. 2010), motivation, needs satisfaction, and perceived success (Butz and Stupnisky 2016).

Key challenges related to synchronous hybrid learning

Apart from the above-mentioned benefits, synchronous hybrid learning also has many challenges.

This results section is divided into the two categories of challenges which are faced in the synchronous hybrid learning settings: pedagogical and technological.

Pedagogical challenges from the teacher perspective

It is stated that this type of learning environment requires radical shifts in the teachers' pedagogical methods in order to accommodate to the new technology (Cain 2015; Ramsey et al. 2016). More specifically, Weitze (2015) provided an adequate description of the influence that technology has:

> Although technologies are physical tools and not theoretical thinking tools or concepts, they change not only the way we carry out a task, but also the way we think about the task. (McLuhan 1964; Hasse and Storgaard Brok 2015 as found in Weitze 2015, p. 1).

The synchronous hybrid learning environment requires a new kind of setup that highly influences the pedagogical and learning design (Weitze et al. 2013), and thus it demands other methods of teaching and different activating learning activities (Bower et al. 2015). This means that the teacher or trainer has to adapt his/her teaching approach, but simultaneously has to maintain comparable learning standards (Grant and Cheon 2007; Lightner and Lightner-Laws 2016). In addition, because the quality of the teaching is partly dependent on the teacher's or trainer's competence in using the technology (Bower et al. 2015), the teacher or trainer needs to actively learn how to work with the technology and get opportunities to try things out and evaluate the outcomes on the basis of evidence (Grant and Cheon 2007; Weitze et al. 2013).

Another challenge is that the synchronous hybrid learning environment requires more coordination from the teacher (Ørngreen et al. 2015). During the instruction in these new

learning settings, the teacher needs to pay attention to both locations and also needs to perform certain operational actions on the teaching and learning platform. It was found that the teacher or instructor has a heavy mental load, which is referred to as hyper-zoom or hyper-focus (Bower et al. 2015; Ørngreen et al. 2015; Zydney et al. 2019).

Pedagogical challenges from the student perspective

Concerning students' perspectives in this new learning environment, research comparing the experiences of on-site students and remote students revealed that these two groups experience the lesson differently in the hybrid synchronous situation (Beatty 2007a, b; Szeto 2014; Zydney et al. 2019). Therefore, it is important to take this into account when preparing the learning experience. What drives the approach of synchronous hybrid learning is the desire to ensure that all students receive comparable learning experiences regardless of location (Butz et al. 2016). The challenges, however, lie in designing and implementing both pedagogical strategies and technological systems that enact those comparable learning experiences (Cain et al. 2016), also referred to as co-presence (Bower et al. 2014). For example, it is imperative that the teacher does not only focuses attention on the remote students and adopts a slower pace with lots of repetition, because these kind of strategies could compromise the class experience of the on-site students (Bower et al. 2015; Szeto 2014).

The study by Olt (2018) specifically aimed to investigate the phenomenon of synchronous hybrid learning from the perspective of the remote participant and concluded that the experience of the remote participant can be best explained and understood using the concept of 'ambiguity' with regard to group membership, functionality of technology, and place. Also Huang et al. (2017) showed that the remote students still felt excluded from the chief class, because they were physically separated from the on-site class, especially when the remote class encountered technical difficulties without immediate support. Meanwhile, on-site students can feel neglected when a teacher spent much time solving the technical problems.

In general, it has been found that, when implementing synchronous hybrid learning, it also gets more difficult to activate and engage the remote students to the same degree as the students attending face-to-face. In the study of Weitze (2015), both students and teachers state that remote students learned less, were generally more passive and often behaved as if they were watching TV and not attending a lesson. One of the reasons for this finding is that teachers give classes based on more monologue-based teaching strategies, which are not well-suited for this kind of learning settings as described above.

In the study of Weitze et al. (2013), remote students indicated that it is difficult to make the teacher aware that they want to answer a question, which makes them frustrated and uninvolved. Therefore, it is important to take this into consideration in the design of the classes and to be aware that remote students need to be encouraged more to be involved in the class activity (Weitze et al. 2013). Further, remote learners feel a significant sense of distance from their institution. This illuminates the need to address the perceived distance between remote students and their teachers and on-site classmates by establishing some sort of connectedness (Ramsey et al. 2016).

Lastly, the synchronous hybrid learning environment demands more self-discipline from students who are following remotely or online (Wiles and Ball 2013). Because the teacher is not physically present, there is less control of the students' engagement.

Technological challenges

An important question in relation to the pedagogical challenges is what the most effective technologies are for maximising the social presence of remote students (Zydney et al. 2019). Often, a disadvantage of the learning environment is the loss of visual and audible cues which normally are observable from the students when they are on-site (Weitze et al. 2013). Therefore, it is imperative that the teacher tries to ensure that remote students always feel included in the class in order to reduce some of the distancing effects. For instance, the lecturer should frequently ask questions throughout the lesson and be attentive to students' input (McGovern and Barnes 2009; Ørngreen et al. 2015).

The biggest challenge faced in the synchronous hybrid learning environment is the audio component which is important for success (Bower et al. 2015; Cunningham 2014; Zydney et al. 2019). Students who follow the class remotely should receive the same audio quality as those students who are present face-to-face (McGovern and Barnes 2009). Therefore, setting up and testing the technology in advance is of great importance for the effectiveness of synchronous hybrid learning activities. Bower et al. (2015) suggested allowing remote students to log in prior to the session, so that there is sufficient time to test and resolve possible problems.

In addition, the technology can be an imposition for the teacher and the on-site students if they need to be conscious of the orientation and positioning of cameras or are required to speak into a microphone which interrupts conversational flow (Cunningham 2014; Bower et al. 2015; Zydney et al. 2019). Nortvig (2013) also noticed that, in these new learning spaces, the technology is very visible (e.g. the camera is visible and it is apparent when it is recording and streaming to remote students). This situation can make teachers very aware of their teaching performance and can cause them to act differently (Nortvig 2013). Next, innovative technologies are continuously altered, which can be frustrating for teachers. It also has been found that small usability issues, caused by the continuous updates of innovative technologies, can confuse, delay or hinder the learning process students (Bell et al. 2014; Weitze 2015).

Lastly, when students disappear from the screen (e.g. because of a bad connection), this can increase the stress level of the teacher. As a consequence, many teachers experience a fatigue after teaching in this learning setting (Weitze et al. 2013). Zydney et al. (2019) more specifically indicated that experienced instructors can facilitate both on-site and remote students without the aid of technical support when groups are limited to eight or fewer on-site students because a single omnidirectional speakerphone can adequately cover the area required to gather a class of this size around it and a swivel device can capture and display students as they speak. However, it is stressed that larger class sizes necessitate different approaches to facilitation.

Design guidelines in response to challenges of synchronous hybrid learning

Guidelines related to training and support

Both the change in pedagogical methods and the use of technology necessitate more preparation and organisation, resulting in an increased workload (Bower et al. 2015; Wiles and Ball 2013). This means that it is important that the educational institution provides sufficient training and support for teachers, both pedagogically and technologically (Bower

et al. 2015; Cain 2015; Lightner and Lightner-Laws 2016; Szeto 2014). As stated by Cain (2015), a possible solution for the many challenges that teachers face in this new context is the use of a technology navigator or operator. This person should be present in every class session to help troubleshoot problems both inside the classroom and online. The technology navigator or operator also has a role in preparing the course and advising teachers regarding pedagogical questions. Once the course has started, students can interact directly with the navigator or operator through, for example, a chat room in the online platform (Cain 2015; Cain et al. 2016). Also Zydney et al. (2019) suggest that students can take up more roles, such as 'chat tracker' and 'technology troubleshooter'. They revealed that this solution not only relieves some of the instructor's pressure to try to manage everything, but can create a more student-centred learning environment and enable more student ownership of the learning environment.

For students, some kind of technological training on how to use and familiarise themselves with the online platform is required (McGovern and Barnes 2009; White et al. 2010). That way, they learn how to log on, enter a lesson and use all the tools that the platform has to offer, such as silent questions or chat possibilities (Ramsey et al. 2016). Further, it is stressed that adequate instructions must be provided to students. By communicating the need to purchase a headset, recommending students to connect through LAN rather than wirelessly, and asking them to run audio and video checks prior to the first lesson, the most typical problems can already be addressed outside class (Ramsey et al. 2016).

Guidelines related to clear communication

When a teacher decides to use the synchronous hybrid learning environment, Ørngreen et al. (2015) stress that a clear vision and expectations must be communicated to the students. For instance, it is a good idea to prepare alternative resolutions in advance and agree with students about what they should work on when a connection cannot be established (Grant and Cheon 2007). Next to communication about the technical requirements, a crucial pedagogical practice is to be explicit to students about how the hybrid synchronous sessions support the overall course learning objectives (Bower et al. 2014; Zydney et al. 2019).

It also is important to communicate very clearly what staff can expect when teaching in a synchronous hybrid learning environment so that they are prepared for the various challenges that they will face and to make the different stakeholders collaborate (Weitze et al. 2013).

Guidelines related to activating learners and curriculum alignment

A possible solution for the engagement problem is cognitively activating students through polls and quizzes and presenting in an active and amusing manner (Bower et al. 2015). In addition, the lecturer should frequently ask oral questions throughout the lesson and be attentive to students' input (McGovern and Barnes 2009; Ørngreen et al. 2015). Lastly, it has been found that the significant sense of distance can be partly resolved by a virtual chat room or discussion forum (Ørngreen et al. 2015). Through this medium, students are able to cooperate, share and contribute to each other's input. In line with the clear communication about learning objectives and the fit with the overall curriculum, it is suggested that synchronous hybrid learning sessions should not be organised as isolated sessions. As suggested by Zydney et al. (2019),

hybrid synchronous sessions should build upon asynchronous activities (e.g. readings or performing exercises) from a flipped classroom approach. These authors also suggest organising breakout sessions to create more student ownership of the learning environment. Bower et al. (2014) reported that co-presence increases when the two cohorts of students are mixed during small group work or breakout sessions, but this design might not always be desirable for practical reasons.

Conclusion and implications for future research, policy and practice

Given that synchronous hybrid learning is relatively new, this study aimed to synthesise the best available evidence worldwide to provide an overview of the state-of-the-art of the current research. This systematic review involved the authors in experiencing and investigating the benefits, challenges and design guidelines regarding technological and pedagogical support for synchronous hybrid learning. We conclude that existing research clearly shows the potential of this emerging practice. Despite the challenges, all studies provided cautious optimism about synchronous hybrid learning, which creates a more-flexible, engaging learning environment compared with fully-online or fully on-site instruction. Based on our review, most of the existing literature is still exploratory and qualitative in nature and has focused mainly on describing students' experiences, organisational implementation and technological design.

In line with several researchers (Abdelmalak and Parra 2016; Bower et al. 2015; Butz and Askim-Lovseth 2015; Butz and Stupnisky 2017; Olt 2018; Zydney et al. 2019), this study suggests that research into synchronous hybrid learning is still in its infancy. As with any complex learning setting, initial development and research leads to many more questions. As an emerging practice, synchronous hybrid education especially needs increased empirical investigation to complement the qualitative case studies. Empirical studies have only begun to emerge and more research is needed into different pedagogical scenarios and their impact on student outcomes. More specifically, the following directions for future work can be identified based on our study. Future research should:

1. Include larger and more-diverse samples to improve generalisability, but also to provide additional statistical power to identify meaningful effects.
2. Include more empirical and longitudinal data with participants to investigate the impact of group membership over time. With multiple data points, future research could also endeavour to longitudinally predict students' assessment results based on learning activities.
3. Include empirical real-time data of the learning experience because engagement, social presence or social belonging are multidimensional concepts that are difficult to measure. Next to self-report data, multimodal learning analytics could be used to better capture and compare students' experiences in different learning settings.
4. Include the effect on student learning and student outcomes across settings and specifically encompass the effectiveness of certain pedagogical scenarios (e.g. quizzes and polls, breakout sessions) for maximising the learning experience and social presence of remote participants.
5. Investigate the most scalable approach with regard to technical and pedagogical capacity and limitations.

We hope that future research can help in achieving the goal of building evidence-based collaborative technologies that will become so invisible that students and teachers interacting from different locations will feel as though they are in the same room (Bower et al. 2015). But, Liu et al. (2018) stress that we still have a long way to go before reaching these desired states.

Next to theoretical implications, we hope that this review supports policy and practice. The study summarises design guidelines for setting up synchronous hybrid learning both from a technical and pedagogical perspective. This study shows that technology has great potential to support current societal transitions and enables people, at any stage of their life, to take part in stimulating learning experiences. However, to ensure that new learning spaces can be implemented on a larger scale, a well thought-out policy is required for dealing with both pedagogical and technical challenges.

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