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 synchronous hybrid learning is relatively new, there a few studies that have investigated its use and effectiveness. This study aimed to synthesize the best available evidence worldwide to have an overview of the state-of-the-art of the current research regarding the benefits, the challenges, and the current design principles to set up synchronous hybrid learning. In line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), this study included 47 studies which were analysed to respond to our research questions. One of the main findings is that existing research express 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 the description of students' experiences, the organizational implementation and the technological design. Empirical studies have only begun to emerge and more research is needed examining different pedagogical scenarios and its impact on student outcomes.

Keywords

Synchronous hybrid or blended learning; Here or There Instruction ; Systematic review; Research gaps

Compliance with Ethical Standards

Conflict of Interest: The authors of this manuscript declare not to have a conflict of interest.

Ethical approval & Informed consent: This research involves no human participants, but includes pictures from a research project which has been reviewed and approved (tracking number: G-2017 09 908) by the Social and Societal Ethics Committee (https://ppw.kuleuven.be/home/onderzoek/SMEC). Informed consent was obtained from all individual participants which are visible on the pictures.

Biography of corresponding author

Annelies Raes holds a PhD in Educational Technology by Ghent University and now works as Postdoctoral Researcher in Instructional Psychology and – Technology at the University of Leuven (KU Leuven), campus Kulak in Kortrijk, Belgium. She is also co-Principal Investigator within imec's Smart Education Program (https://www.imec-int.com/en/articles/smart-education). Her main fields of interests are new innovative education models as active learning and problem-based collaborative learning and how this can be supported by emergent technologies.

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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 life, 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 due to, for example, family or work commitments. Within this context, digital technologies are often put forth 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, Lynch, Rabinovich and Knutel 2014; Roseth, Akcaoglu and Zellner 2013). Previous studies show that different models of synchromodal classes can be designed and implemented (Bell, Sawaya and Cain 2014; Bower, Dalgarno, Kennedy, Lee and Kenney 2014, 2015).

Recently, at the university KU Leuven, two models of synchronous hybrid learning environments have been designed as displayed in Fig. 1.

Fig. 1 Two models of synchronous hybrid learning at the living lab of the university

| **The Remote Classroom** | **The Hybrid Virtual Classroom** |

The picture on the left depicts what we call the "Remote Classroom", 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, McKimmy, Lindberg and Schmidt 2019). The differences between the Remote and the Hybrid Virtual Classroom emerge from the location of which 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 on the left corner of the picture in 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, Stupnisky, Pekrun, Jensen and Harsell 2016; Hastie, Hung, Chen and Kinshuk 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 opportunity to participate in the actual lesson and to interact at a distance with all the 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 and the imec.icon project LECTURE+project. The newly designed learning spaces function as living labs to study 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 the teacher is using during his or her lecture (e.g. power point slides or annotations made on the digital whiteboard), facilitates launching quizzes or polls and is equipped with a chat room which gives students the possibility 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.

Fig. 2 Upper pictures display the Hybrid Virtual Classroom including both F2F and remote individual students. Lower pictures display the platform visible for the students.
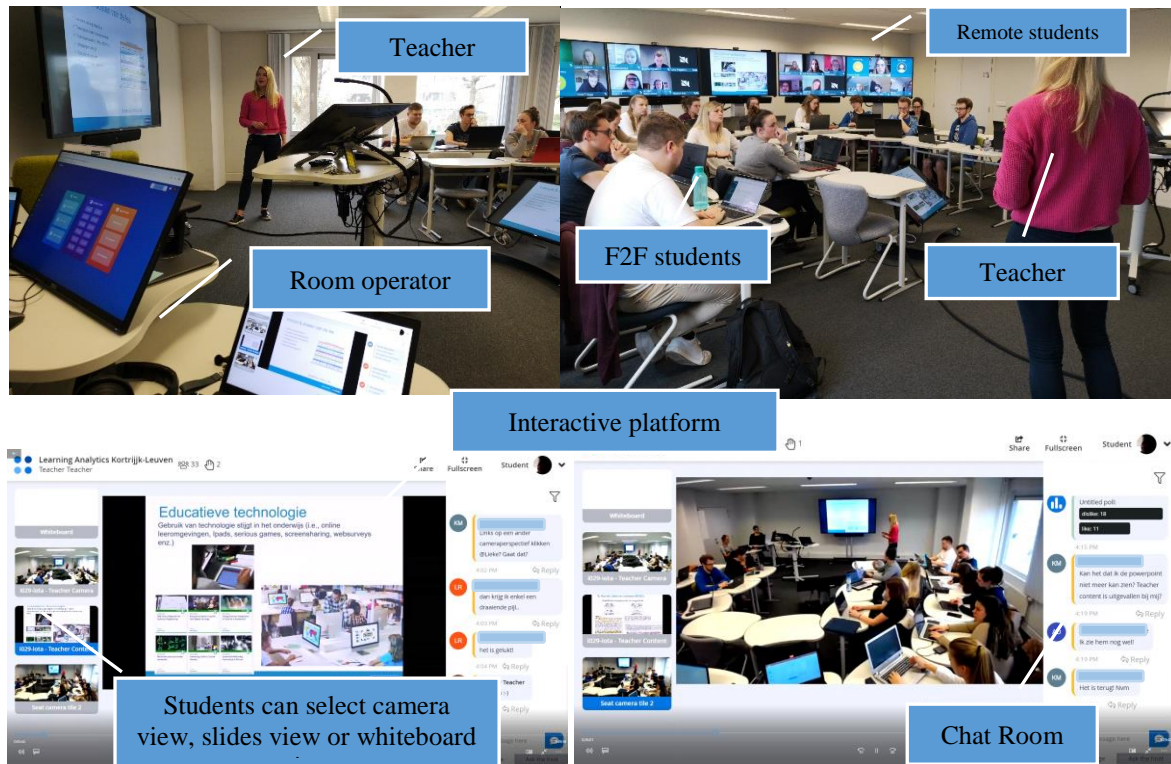
Research objective

At the start of the research project on synchronous hybrid learning we aimed to conduct a systematic review before starting new studies as the research field can learn a lot from earlier studies and prevents both the research field 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, 2010b).

In this case we aimed to summarize existing evidence concerning synchronous hybrid learning with regard to the benefits, the challenges and the 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.

The following review questions are put forth:
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 optimize synchronous hybrid learning?

In what follows, first we outline in detail the methodology we used in the systematic review. Second, the results of 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 based on the findings of this study.

Methodology

Inclusion and exclusion criteria
As the setting under review is 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 did not predefine the population or the topic of interest the study should focus on. Neither, we predefined criteria related to the method of the study as 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 it was studied 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 will not include literature focusing on the pure virtual classroom only 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 (including for example 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; (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. Dependent 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.

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 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, Liberati, Tetzlaff, Altman and The PRISMA Group 2009). The Boolean search query in the four databases resulted in 286 studies, 92 were duplicates. This resulted in 194 studies which were screened based on the title and the abstracts. This identification and screening phase has been completed by the first two authors, independently form each other. It was checked in more detail whether the study involved a synchronous hybrid learning setting, yet in many cases this was not yet clear from the abstract and then these studies were selected for full text screening. In total 72 manuscripts remained for further assessment through reading the full text, which has been done 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) as they did not meet the selection criteria. The most common reason for exclusion was the fact that the research was not investigating synchronous learning situations as stated above. For example, a study reporting about a blended course integrating 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) or a study reporting about synchronous learning but in a pure virtual class without on-site participants (e.g. Baker and Hjarlmarson 2019). Based on the identification of the reference lists of the remaining studies, 11 additional studies were found. This resulted in 47 studies which were analyzed to answer the four research questions (see Table 1). In seven cases, studies were clustered as the publications reported about the same learning setting and/or about the same set of participants.

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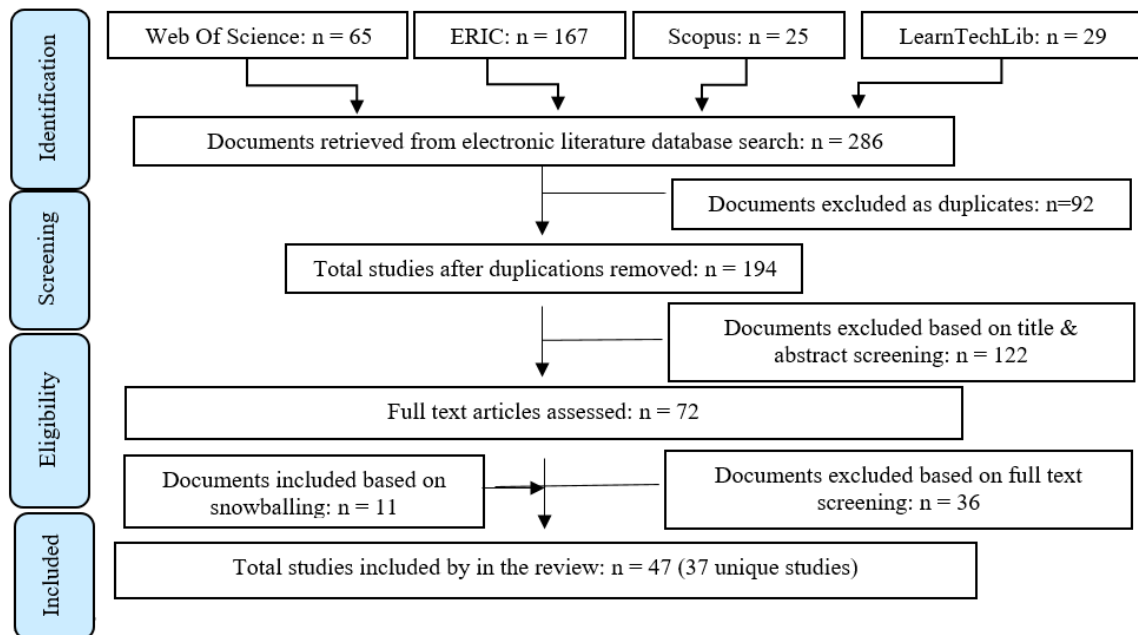
Results

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

To answer Research Question 1, which aims to get insight in the SOTA, each publication was analyzed 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 summarizes the results of this analysis.

The first study on synchronous hybrid learning dates from 2003 and was a qualitative case study aiming to observe 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 (2007, 2010) was pioneering in the development, and evaluation of the HyFlex course design model for blended learning environments. Yet, the most studies date from a later period, i.e. published between 2013 and 2019. Most of the studies are case studies (28 in total), 15 of them using mixed methods, 13 of them only using qualitative analysis. Next, one review study and two conceptual studies were identified. Empirical studies are limited. Only five studies were found taken a comparative approach to study the effectiveness between different modes of delivery. Only one experimental study was found. This study was set up from 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 tackle both the remote and the hybrid virtual classroom in their publication. Lastly, regarding the context of the study almost all studies are conducted in the context of higher or adult education settings. Only one study focused on the pedagogical utilization of remote classrooms in contemporary elementary schools (i.e. Anastasiades et al. 2010).

Table 1 Alphabetical overview of the included studies based on the systematic search

	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, Lynch, Rabinovich and Knutel (2014)	Hybrid virtual classroom N = 171 university students	Mixed methods case study	Providing a 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, Filippousis, Karvunis, Siakas, Tomazinakis, Giza, and Mastoraki (2010)	Remote classroom Context: K12 education – grade 6 N = 45 students and 4 teachers from 2 schools	Mixed methods case study	Presentation of the design, implementation and evaluation of the methodology which focuses on the pedagogical utilization of Interactive Videoconferencing (IVC) in contemporary elementary schools.
4	Beatty (2007, 2010)	Hybrid virtual classroom Context: Adult and higher education 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, Dalgarno, Kennedy, Lee, and Kenney (2014, 2015) and Bower, Lee and Dalgarno (2017)	Remote classroom & hybrid virtual classroom Context: higher education including 7 design cases	A cross-case qualitative analysis study	To examine how design and implementation factors influence student learning activity and perceived learning outcomes and describe this in a Blended Synchronous Learning Design Framework.
7.	Brumfield, Carleo, Kenny, Melendez, O'Neill, Polanin, and Reynolds-Allie (2017)	Remote classroom Context: adult education	Qualitative case study	Description of the concept and the design of the course.
8.	Butz and Askim-	Hybrid virtual classroom	Exploratory quantitative study	Examination of the relationships among attendance mode, student nationality and

		Lovseth (2015)	Context: higher education N = 202 graduate students, 120 on-campus and 82 online	comparing different student groups: online vs. on-campus, and domestic vs. international	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 the experimental group or the 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, Stupnisky, Pekrun, Jensen, and Harsell, (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 vs. on-campus students using longitudinal analyses.	To investigate 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	Description of how instructors and support staff involved in the hybrid program and explanation of their innovative solution, i.e. the role of an in-class technology navigator.
12.		Cain, Bell and Cheng (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 individualization 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 the experiences of both online and campus students in light of social presence and activity theory.

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.	Research on how synchronous conferencing technology affects teaching and learning. Also the exploration of factors bearing on the success and failure of synchronous conferencing in hybrid classes.
15.	Hastie, Hung, Chen and Kinshuk (2010)	Hybrid virtual classroom Context: international collaboration between two educators involving two institutions from two countries in the Asia-Pacific region	Description of nine 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, Shu, Zhao and Huang (2017)	Hybrid virtual classroom Context: five teachers and students from two senior schools in china (N not specified)	Mixed methods case study	Study on (1) how the teachers' activities impact teaching effect in their courses? (2) What do high school students expect of their video-enhanced teachers? (3) What actions do remote students take to achieve good learning experience?
17.	Lakhal, Bateman and Bédard (2017)	Hybrid virtual classroom Context: Higher education	Review study	Description of the advantages, challenges, conditions of success and the 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 In the timeframe of 3 years, there were 112,973 grades issued across 6316 courses.	Investigating the impact of the environment on student performance.
19.	Liu, Spector, and Ikle (2018)	Hybrid virtual classroom Context: four universities were included taking turns in designing, developing and delivering courses in Computational Science and Engineering.	Case study from a developmental approach	Sharing the finding of the project focusing on computer technologies served as the 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	Examination of 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 the concept of embodiment of technology, technological transformation and the influence of technology. |
| 22. | Olt (2018) | Hybrid virtual classroom N = 9 remote students | Qualitative case study using phenomenological methodology | To investigate the phenomenon of using synchronous online classes blended with a face-to-face classroom from the perspective of the remote participant. The study is situated within the initiative "Bridge to Campus" providing the entire freshman year of college through synchronous online coursework. |
| 23. | Ørngreen, Levinsen, Jelsbak, Moller and Bendsen (2015) | Hybrid virtual classroom

Context: The Bachelor Program in Biomedical Laboratory Analysis in Aarhus | Qualitative case study as a participatory action research project | To identify potentials and barriers from an ICT-supported learning perspective; to develop robust educational designs and teaching scenarios, and to qualify teaching staff in teaching activities which involves the use of the blended class model. |
| 24. | Ramsey, Evans and Levy (2016) | Hybrid virtual classroom

Context: Public university

N = 19 | Mixed methods case study | To present preliminary reflections on their initial experiences and present their survey data regarding students' experiences. |
| 25. | Rasmussen (2003) | Hybrid virtual classroom

N = 6 remote students living in various parts of the western United States + 11 face-to-face students on campus | Qualitative case study | To observe the quantity and quality of human interaction between the instructor, the 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 | To help inform the design of hybrid synchronous instruction and to understand the effectiveness and efficiency of hybrid synchronous instruction from the perspective of the distance learners. |
| 27. | Roseth, Akcaoglu | Hybrid virtual classroom | Conceptual study | Description of the rationale behind pedagogical choices and specification of |

	and Zellner (2013)	Context: Hybrid Doctoral Seminar		various technologies to create a virtual classroom.
28.	Shen, Wang, and Pan (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, Harlow and DeBacco (2011) | Hybrid virtual classroom

N = 46 graduate students were enrolled in different courses held over the two year project | Mixed methods ethnographic study | Studying the experiences of learners participating in multi-site education classes. |
| 30. | Szeto and Cheng (2016) and 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 | Studying the 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 were analyzed: semester 1: N = 15semester 2: N = 13 | Mixed methods case study | Exploration of 1) students' choices of verbal and text interaction and 2) students' preference for online or remote participation when given the choice. |
| 32. | Wang, Quek and Hu (2017); Wang, Huang and Quek (2018); Wang and Huang (2018) | Hybrid virtual classroom

N = 24 graduate students (in-service school teachers) during 13 sessions of 3 hours | 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, Ørngreen and Levinsen (2013)	Hybrid virtual classroom Context: adult learning 2 classes included N =10 + N = 26	Mixed methods case study with focus on design perspective	Description of students' experiences, the organizational implementation and the development of instructional design, the IT-Pedagogical Think Tank for Teacher Teams.
34.	White, Ramirez, Smith and Plonowski (2010)	Hybrid virtual classroom Context: higher education N = 10 participants	Mixed methods case study	Determination of the feasibility of delivering a course on-campus and in real time, simultaneously transmitting it to students who were remotely accessing the same course.
35.	Wiles and Ball (2013)	Hybrid virtual classroom Context: Undergraduate	Longitudinal mixed methods case study	Description of the design of the converged classroom and presenting the benefits and challenges.

		students, 3707 enrollments over 7 semesters		
36.	Yen and Abdous (2012)	Combination of Hybrid virtual and remote classroom N = 496 university students	Empirical study	Exploration of the 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, McKimmy, Lindberg and Schmidt (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	Illustration of different implementations of "Here or There instruction", explanation of the affordances of these varied approaches, and provision of the best practices.

Benefits of synchronous hybrid learning

Below we summarize 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 the grounded theory (Glaser and Strauss 1967). The data were read and reread to identify and index the found benefits. Through this process, benefits could be categorized into two categories, namely (1) organizational benefits related to 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 due to the increased offering of distance and online education. The synchronous hybrid learning environment could provide an answer to this problem and help to increase the recruitment rates. This because, by offering the possibility to attend face-to-face or remote, the institution can reach out to a greater base of potential students (Abdelmalak and Parra 2016; Butz and Askim-Lovseth 2015; Ørngreen et al. 2015; Wang, Quek and Hu 2017; Wiles and Ball 2013). The hybrid virtual setting more specifically can ensure access to education regardless of place which provides more inclusive education and equality in learning outcomes (Bower, Dalgarno, Kennedy, Lee and Kenney 2015; Weitze, Ørngreen and Levinsen 2013). Moreover, it is possible to offer more elective or specific courses which are normally taught at one specific location and external experts can be consulted more easily; this makes that the personal interests of the students and learners are better addressed (Bell, Sawaya and Cain 2014; McGovern and Barnes, 2009). Another organizational benefit is that the hybrid virtual classroom eliminates the need to teach the same course twice to different classes at different campuses which reduce workloads on a small educational team (Bell, Sawaya and Cain, 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 this learning environment offers. Hence, one of the most cited benefits is flexibility in course attendance for the students. For example, when a student is ill or when he cannot move to the campus where the teacher will be present, there is the opportunity to follow remotely through online participation. This kind of flexibility is more in line with the current society we are living in (Lakhal, Bateman and Bédard 2017; Wang, Quek and Hu 2017; Wiles and Ball 2013). In addition, these learning environments accommodate for job & family commitments and thus take a multifaceted student population into account (Lightner and Lighnter-Laws 2016; Wiley and Ball 2013).

Pedagogical benefits

Next to organizational benefits, the hybrid virtual classroom offers the possibility to include expertise outside the institution meaning that students are being 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, Spector and Ikle (2018) stressed the social benefit to students included providing equal learning opportunities to under-represented students. Likewise, the synchronous hybrid learning environment can guarantee continuity of instruction and promotes student retention (Lakhal, Bateman and Bédard 2017; Ramsey, Evans and Levy 2016; Wang, Quek and Hu 2017; Wiley and Ball 2013). Weitze, Ørngreen and Levinsen (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. (Weitze, Ørngreen and Levinsen 2013, p. 5)

As mentioned in the citation, synchronous hybrid teaching offers the possibility to maintain the guidance and comfort of traditional courses for both remote students and for the students 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; Wiley 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 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 done empirical research to assess the differences between the outcomes of students who attend online versus in-person, yet the existing studies (Lightner and Lightner-Laws 2016; Szeto 2014; White, Ramirez, Smith and Plonowski 2010) provide evidence for the notion that flexible course delivery options have little to no negative impact on student learning as it results in similar learning outcomes, such as test scores (White et al. 2010), and motivation, needs satisfaction, and perceived success (Butz and Stupnisky 2016)

Key challenges related to synchronous hybrid learning

Apart from the above mentioned benefits, the synchronous hybrid learning also has many challenges.
This result section is divided into the two categories of challenges which are faced in the synchronous hybrid learning settings: i.e. pedagogical and technological challenges.

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, Evans and Levy 2016). More specific, Weitze (2015) provided an adequate description of the influence 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 influence the pedagogic and learning design (Weitze, Ørngreen and Levinsen 2013), and thus 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 Lighnter-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 has to 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 setting, the teacher needs to pay attention to both locations and also needs to perform certain operational actions on the teaching and learning platform. Hereby, it is 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, McKimmy, Lindberg and Schmidt 2019).

From the student perspective
When looking at the students' perspective in this new learning environment, research comparing the experiences of on-site students and remote students found that these two groups experience the lesson differently in the hybrid synchronous situation (Beatty 2007, 2010; 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 all students are receiving comparable learning experiences regardless of location (Butz, Stupnisky, Pekrun, Jensen and Harsell 2016). The challenges, however, lie in designing and implementing both pedagogical strategies and technological systems that enact those comparable learning experiences (Cain, Bell and Cheng 2016), also referred to as co-presence (Bower et al. 2014). For example, it is imperative that the teacher not only focuses his attention on the remote students and adopts a slower pace with lots of repetition, as these kind of strategies could compromise the class experience of the on-site students (Bower et al. 2015; Szeto 2014). The study of 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 by the concept of 'ambiguity' with regard to group membership, functionality of technology, and place. Also Huang, Shu, Zhao and Huang (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 encounters 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 gets also 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 like 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 more invited into 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, Evans and Levy 2016).

Lastly, the synchronous hybrid learning environment demands more self-discipline from students who are following remotely or online (Wiles and Ball 2013). Since 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 maximizing 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 the 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 needs to 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 found to be decisive for success (Bower et al. 2015; Cunningham 2014; Zydney et al. 2019). It is stated that 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 to let remote students log in prior to the session, so 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, for instance if they need to be conscious of the orientation and positioning of cameras or if they 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, for example, 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 is also found that small usability issues, caused by the continuous updates of innovative technologies, may confuse, delay or hinder the learning process of the students (Bell et al. 2014; Weitze 2015).

Lastly, when students disappear from the screen because there is, for example a bad connection, this can induce the stress-level of the teacher. As a consequence, many teachers experience an immense 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 as a single omnidirectional speakerphone can adequately cover the area required to gather a class of this size around it and a swivl device can capture and display the students as they speak. However, it is stressed that larger class sizes will necessitate different approaches to facilitation.

Design guidelines in response to the challenges of synchronous hybrid learning

Guidelines related to training and support

Both the change in pedagogical methods and the use of technology ask for more preparation and organization, 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 has also a role in preparing the course and can advise teacher regarding pedagogical questions. One the course has started, students can interact directly to the navigator or operator through, for example, a chat room in the online platform (Cain 2015; Cain, Bell and Cheng 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 take off some of the instructor's pressure to try to manage everything. Also, this can create a more student-centered learning environment, enabling more student ownership of the learning environment.

Also for students, some kind of technological training on how to use and familiarize 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 the platform has to offer, such as silent questions or chat possibilities (Ramsey, Evans and Levy 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 of 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 faculty staff can expect when teaching in a synchronous hybrid learning environment so they are prepared for the various challenges 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 student 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 needs to 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 organized as isolated sessions. As suggested by Zydney et al. (2019), hybrid synchronous sessions should built upon asynchronous activities (e.g. readings or performing exercises) from a flipped classroom approach. These authors also suggest to organize 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, however, they note this design may not always be desirable for practical reasons.

Conclusion and implications for future research, policy and practice

Given synchronous hybrid learning is relatively new, this study aimed to synthesize the best available evidence worldwide to have an overview of the state-of-the-art of the current research. This systematic review brought together the authors experiencing and investigating the benefits, challenges and design guidelines regarding technological and pedagogical support for synchronous hybrid learning. We can conclude that existing research

clearly shows the potential of this emerging practice. Despite the challenges, all studies express cautious optimism about synchronous hybrid learning which creates a more flexible, engaging learning environment compared to fully online or fully on-site instruction. Based on our review, we can conclude that most of the existing literature is still exploratory and qualitative in nature and has focused mostly on the description of students' experiences, the organizational implementation and the 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 can conclude that the research into synchronous hybrid learning is still in its infancy. It can be stated that, 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 examining different pedagogical scenarios and its impact on student outcomes. More specifically, the following directions for future work can be defined based on the results of this study:

1. Future research should include larger and more diverse samples to improve generalizability, but also to provide additional statistical power to identify meaningful effects.
2. Future research should include more empirical and longitudinal data of the participants to investigate the impact of group membership over time. With multiple data points, future research could also endeavor to longitudinally predict students' assessment results based on learning activities.
3. Future research should include empirical real-time data of the learner experience as engagement, social presence or social belonging are multidimensional concepts 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. Future research should include the effect on student learning and student outcomes across settings and specifically investigate the effectiveness of certain pedagogical scenarios (e.g. quizzes and polls, breakout sessions) for maximizing the learning experience and social presence of remote participants.
5. Future research should 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 to build 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). Yet, Liu et al. (2018) stress that we still have a long way to reach to these desired states.

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

Endnote

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.

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Studies marked with * are included in the literature review, see also Table 1

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