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Systematic Review

Hybrid Teaching and Learning in Higher Education: A Systematic Literature Review

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Abstract: Hybrid teaching, which integrates traditional in-person learning based on students' perspectives where online learning offers a flexible approach to education, combines the benefits of technology with face-to-face interactions. Moreover, teaching and learning in a hybrid way met several challenges for both teachers and learners, including technological problems, time management, communication difficulties, and assessment complexities. This systematic review investigates six main research questions: (1) What pedagogical frameworks are used in hybrid teaching and learning? (2) How can we enhance students' engagement in hybrid teaching and learning? (3) What is the impact of technological integration on hybrid learning scenarios, both for students and teachers? (4) How do training and support measures influence the willingness and ability of university teachers to implement hybrid teaching formats? (5) How do formative assessment and feedback methods in hybrid learning environments enable teachers to effectively monitor student progress and provide tailored support? (6) How does the implementation of hybrid learning affect student learning outcomes? This study identifies the following key themes: technological integration, pedagogical innovation, faculty support, student engagement, assessment practices, and learning outcomes. Our contribution of this literature review is related to teaching and learning by showing teachers the most appropriate way to avoid the challenges encountered when teaching in a hybrid way. These include strong technology integration, innovative pedagogical strategies, strong academic development and support, active student engagement, effective assessment practices, and positive learning outcomes.

Keywords: hybrid learning; hybrid teaching; higher education; hybrid learning challenges; technological integration

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1. Introduction

Hybrid teaching synchronously combines traditional in-person teaching with online or remote teaching, offering a flexible and adaptable approach to education. This method allows educators to incorporate technology and digital resources into their teaching while maintaining face-to-face interactions with students. Falling under the umbrella of blended learning, hybrid teaching is increasingly used to describe the integration of e-learning with

a traditional classroom on campus [1]. Hybrid learning combines traditional in-person instruction with online components that complement the classroom experience and offer a flexible and engaging learning environment. This approach typically involves synchronous participation, allowing for real-time communication between in-person and remote students [2]. Despite varied definitions of hybrid learning, common aspects include (1) the technologies required to facilitate hybrid teaching and learning, (2) synchronous teaching by learning in present time online, and (3) the integration of in-person and virtual instruction. The concept of hybrid teaching has gained significant attention in educational discourse, as scholars attempt to define and refine its implementation in diverse learning environments. For example, Linder [3] refers to hybrid pedagogy as a "method of teaching that uses technology to create a variety of learning environments for students. Instructors who employ hybrid pedagogies intentionally incorporate technology tools both to enhance student learning and to respond to a wide range of learning preferences". Ulla and Perales [4], although acknowledging that studies in the literature do not present a clear definition of hybrid teaching, define hybrid teaching as "synchronous teaching of students in the classroom and online using an online platform". Synchronous and asynchronous learning modes differ in several key respects. Synchronous learning involves real-time communication, whereas asynchronous learning allows participants to communicate in the virtual environment in different times and from different locations. Both modes employ different strategies, methods, and objectives and use different forms of interaction. An asynchronous environment offers a high degree of interactivity despite geographic and temporal separation, suggesting greater flexibility for learners. However, both modes present unique challenges for teachers, institutions, and students [5]. Yeo [6] specifies that with hybrid or hyflex teaching, "we have students in the classroom with us physically in-person, and we also have students who are joining us virtually, synchronously through video conferencing software, simultaneously". Lorenzo-Lledoó et al. [7] describe hybrid teaching as a dual teaching modality "where students have the option of attending the assigned classes in-person and, for the rest of the classes, they can follow the programmed content online". O'Byrne and Pytash [8] defined hybrid or blended learning as a pedagogical approach that includes a combination of face-to-face instruction with computer-mediated instruction. The terms blended learning, hybrid learning, and mixed mode learning are used interchangeably in current research; however, in the United States, hybrid learning is used most frequently. Although hybrid learning can be diverse in how it is implemented, educators agree that this approach can provide personalized instructions with some elements of student control over the path, pace, time, and place.

As hybrid teaching and learning models in university course delivery have grown rapidly over the last decade, academics often face various challenges. There are many challenges for teachers to teach in a hybrid way and to design a curriculum for hybrid teaching. For example, the teaching process can be met with a plethora of technical issues [9], such as unreliable Internet connections, software glitches, and hardware failures, which can disrupt the learning experience for both students and teachers. During hybrid teaching, it is crucial that all participants have access to the necessary technology, and providing support for technical issues is essential [10]. Furthermore, effective time management is critical in hybrid teaching, as students must balance online and in-person classes, assignments, and self-directed study [11,12]. Another challenge pertains to communication and collaboration. In a hybrid teaching environment, effective communication and collaboration can be significantly more difficult. Coordinating schedules, sharing resources, and collaborating on projects pose challenges for both students and teachers when interactions are split between online and in-person formats. Additionally, assessing students' performance in a hybrid setting is complex. Academics must adapt their assessment methods to integrate both

in-person and online components, ensuring the integrity and fairness of the assessment process [13,14]. Moreover, there can be challenges in terms of curriculum design, i.e., designing a curriculum that seamlessly integrates in-person and online components presents several challenges. Educators must carefully structure the learning experience to maximize the benefits of each mode while minimizing their respective drawbacks [15]. A significant challenge is securing the data security and privacy components of the Internet. The use of various online tools and platforms raises concerns about protecting sensitive information. Organizational managers and academics must be vigilant and implement robust measures to protect student data by suggesting learners use safe tools and environments [16,17]. Furthermore, students in a hybrid learning environment may require additional support and resources, including access to online platforms, academic advice, and technical assistance [18]. However, hybrid teaching requires a change in pedagogical approaches, as academics must find new ways to engage students and facilitate learning in both in-person and online settings. This can be a serious challenge for academics and educational institutions since there is a need to invest in infrastructure, training, and support systems that enable effective hybrid teaching and learning. Flexibility, adaptability, and a commitment to providing equitable educational opportunities are crucial to successfully navigate the complexities of hybrid teaching [19].

In line with the mentioned challenges, this study is divided into the following research questions (RQs):

RQ1: *What pedagogical frameworks are used in hybrid teaching and learning?*

RQ2: *How can we enhance students' engagement in hybrid teaching and learning?*

RQ3: *What is the impact of technological integration on hybrid learning scenarios, both for students and teachers?*

RQ4: *How do training and support measures influence the willingness and ability of university teachers to implement hybrid teaching formats?*

RQ5: *How do formative assessment and feedback methods in hybrid learning environments enable teachers to effectively monitor student progress and provide tailored support?*

RQ6: *How does the implementation of hybrid learning affect student learning outcomes?*

With this study, we aim to provide insights into how to implement effective hybrid learning practices, increase student engagement, integrate technology, and provide tailored support through improved assessment and feedback methods in hybrid learning. The remainder of this paper is structured as follows. Section 2 describes the methodological approach used in this study. Section 3 presents the results and discussion of this study, and Section 4 concludes this paper by summarizing the main findings, implications, and contributions of this study.

2. Methodological Approach

This study employs a systematic literature review (SLR) following the guidelines outlined in the "Preferred Reporting Items for Systematic Review and Meta-analysis Protocols" (PRISMA) [20]. PRISMA provides a structured framework, consisting of a checklist (as can be seen in Supplementary File S1) and a flow chart, which work together to systematically identify, screen, assess eligibility, and include studies in the review. A flow chart (Figure 1) provides a visual representation of the selection process, helping to track the number of included and excluded studies at each stage with detailed justifications.

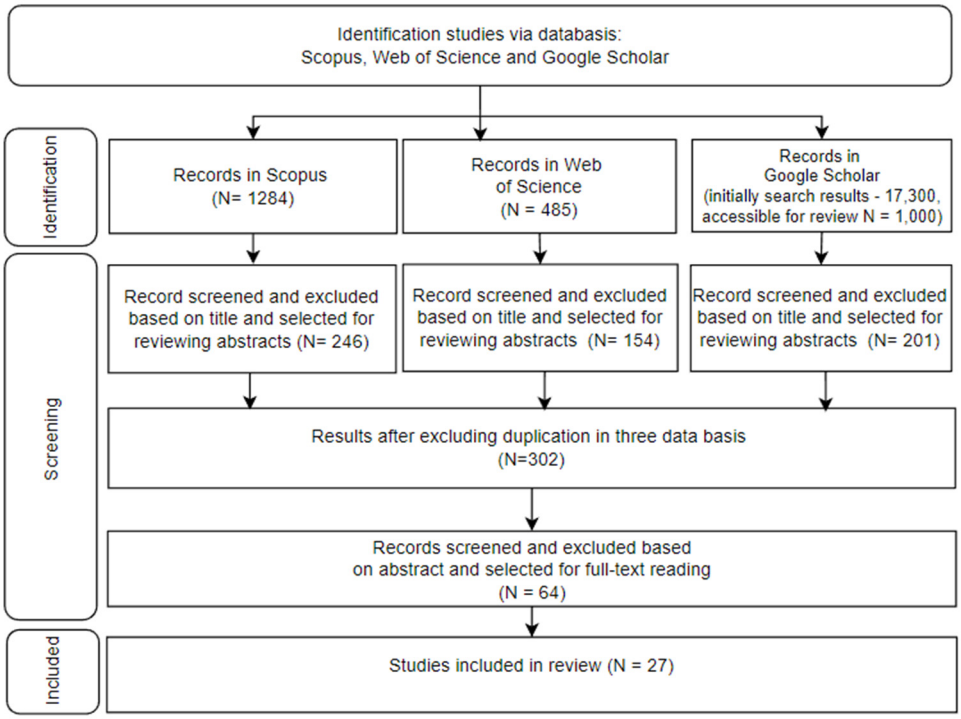

Figure 1. Prisma framework to obtain the relevant studies.

2.1. Eligibility Criteria and Study Selection

To gain a comprehensive overview of the literature on hybrid teaching and learning, we carried out a literature search to identify as many relevant publications as possible by using Microsoft Edge. The process began with a search using terms commonly associated with this topic. The search was limited to publications in English and focused on articles published between 2014 and 2023. This period was chosen to capture the latest developments and innovations in hybrid teaching and learning, especially given that the integration of technology into education has accelerated in recent years. The inclusion of only English language publications ensured that the studies were widely understood by an international academic audience.

For the literature search, we used the most relevant electronic databases available at our institutions for educational research: Web of Science, Scopus, and Google Scholar. These databases were selected for their high coverage of peer reviewed publications and their relevance to educational research.

To ensure the use of appropriate primary search terms and the careful selection of relevant articles for review, the literature search method involved a key search string that was consistently applied in all databases. Publications on hybrid teaching and learning were identified using keyword grouped as follows: (a) hybrid learning, hybrid teaching, hybrid education; (b) synchronous, online, blended, distance; (c) higher education, university, faculty, students. Within each group, search terms were linked with the Boolean operator OR, and the groups were combined using the Boolean operator AND (see Table 1). The search included published conceptual or empirical research such as articles, conference papers, and books. To incorporate diverse perspectives and challenge Eurocentric models, the search scope was expanded to beyond Europe.

Several steps of a systematic review methodology protocol commonly used across fields [21] and specifically within educational research [22] were also performed. Moreover, according to Tomassi et al. [23], we are analyzing the role of chatbots and AI in spreading misleading information in society. These aspects and steps are presented below.

Table 1. Search string used for selecting the documents.

"hybrid learning" OR "hybrid teaching" OR "hybrid education"	AND	"synchronous" OR "online" OR "blended" OR "distance"	AND	"higher education" OR "university" OR "faculty" OR "students"

2.2. Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were established to ensure that only relevant and high-quality studies focused on hybrid teaching and learning in higher education were selected (see Table 2). The inclusion criteria helped identify articles that met the scope of this study, while the exclusion criteria filtered out those that were irrelevant or did not meet the standards required for the review. The primary reason for excluding some articles was the different definitions of key concepts, such as using 'blended' or 'hybrid' to refer to synchronous teaching and learning activities. The focus was on hybrid learning, that is education in which the face-to-face classroom experience is combined with an online experience.

Table 2. Inclusion and exclusion criteria of articles.

Inclusion Criteria	Exclusion Criteria
1. Articles published in the years 2014–2023, reflecting recent developments and innovations in hybrid teaching and learning.	1. Studies that did not directly examine the basic concepts of hybrid learning or its practical implementation in higher education.
2. Peer reviewed articles.	2. Publications not in English.
3. Studies with a primary focus on hybrid teaching and learning in higher education which (1) discussed the challenges in implementing the hybrid model, (2) identified best practices and common pitfalls in hybrid teaching and learning activities, (3) presented findings directly relevant to higher education, and (4) were sustained on empirical research.	3. Articles beyond the specified publication date.

The initial search resulted in 19,069 articles, which were significantly reduced following the exclusion criteria. The Google Scholar search initially yielded 17,300 articles, but due to database limitations, only 1000 results were available for review. The articles with unrelated titles were then removed, reducing the total number from 2769 to 601. After removing duplicates, 302 studies remained, which were screened based on their abstracts. The abstracts of the remaining articles were next examined, narrowing the selection down to 64. Finally, after a comprehensive full-text analysis, 27 articles were selected to address and analyses the six research questions. Figure 1 summarizes the process of study identification, screening, and selection for review. The process resulted in a final selection of studies to be included in the review, providing a comprehensive and focused analysis of hybrid teaching and learning in higher education.

2.3. Data Analysis

After screening, 27 articles were selected for detailed analysis. Then, we analyzed the content of these articles, categorizing key insights under themes such as 'student experiences', 'teacher experiences', 'student benefits', 'modes of hybrid teaching', 'technological integration', and 'design strategies'. This process involved categorizing key themes and patterns as they emerged from the data, allowing researchers to systematically organize

and interpret various aspects of hybrid teaching and learning. In the next step, the findings were grouped based on the experiences and perceptions of teachers, as well as those of online and on-site student populations, to pinpoint the key challenges in delivering hybrid education. Finally, the findings regarding possible strategies, solutions, tips and, tricks were clustered in relation to these challenges.

The following section of this article provides insights from the reviewed articles. For ease of understanding, the selected findings are organized and presented in tables, thus improving the accessibility and understanding of the analysis.

3. Results

After the review of the papers, we identified the following criteria that made the biggest impact on the quality of teaching and learning in a hybrid way: (1) pedagogical framework, (2) enhancing student engagement, (3) technological integration, (4) academic development, (5) assessment and feedback, and (6) evaluation of students' learning outcomes (see Table 3).

Table 3. Identified papers according to the selected criteria.

Authors	Year	Pedagogical Framework	Enhancing Student Engagement	Technological Integration	Academic Development	Assessment and Feedback	Evaluation of Students' Learning Outcomes'
Alhusban [24]	2022	+	+		+	+	+
Ayub et al. [25]	2022	+	+	+		+	
Butz and Askim-Lovseth [26]	2015	+	+				
Butz and Stupnisky [27]	2016	+	+				
Butz et al. [28]	2016				+		+
Cain and Bell [29]	2017			+			
Cain et al. [30]	2016	+	+	+			
Capello et al. [31]	2022	+	+	+	+		+
Carruana Martín et al. [32]	2021	+	+	+		+	
Cohen et al. [33]	2020		+				
Gleason and Greenhow [34]	2017	+	+	+	+		
Han et al. [35]	2022						+
Hayes and Tucker [36]	2021	+	+				
Li et al. [37]	2021						+
Lohiniva and Isomottonen [38]	2021						+
Nørgård [39]	2021	+					
Nykvist et al. [40]	2021						+
O'Byrne and Pytash [8]	2015	+					
Okoye et al. [41]	2021			+			+
Pham and Tran [42]	2022	+					
Raes [43]	2022			+			+
Raes et al. [2]	2020	+					
Rodríguez et al. [44]	2022		+				
Schumann et al. [45]	2021		+		+		
Subramanian [46]	2022		+	+	+		
Ulla and Perales [4]	2022				+		
Zydney et al. [47]	2019	+					

Table 3 highlights various areas of research. The "+" symbol indicates that the corresponding study contains discussions or content related to the specific topic listed in the

column heading. Although the reviewed articles covered a wide range of topics related to hybrid learning, the results in this section are presented selectively to directly answer the research questions posed in this study.

RQ1: *What pedagogical frameworks are used in hybrid teaching and learning?*

Table 4 presents an overview of studies that focus on hybrid teaching and learning environments, emphasizing the importance of adopting sound pedagogical frameworks to integrate face-to-face and online components, thus improving student learning experiences. Common pedagogical models such as blended learning, flipped classrooms, and active learning are frequently cited as effective approaches in these hybrid settings. Flipped learning is a pedagogical approach that inverts traditional teaching by moving content outside the classroom and using class time for active learning activities. It combines the use of online content with face-to-face interactive sessions, making it a form of hybrid learning. This method aims to enhance student engagement, promote higher-order thinking skills, and shift to student-centered learning. The practical implementation of the principles of flipped learning is flipped classrooms. Meanwhile, active learning in hybrid education involves teaching methods that engage students in meaningful activities and thinking processes. This approach promotes higher-level cognitive skills, student engagement, and collaborative learning [48].

Table 4. Pedagogical aspects.

Study	Pedagogical Aspects Discussed by Authors	Research Method
Alhusban [24]	Synchronous hybrid learning method (SHLM), combining F-2-F and virtual teaching simultaneously using real-time audio and video technology, allowing interaction between two groups of students who alternate between online and face-to-face classes. This model allowed students to attend 50% of their classes face-to-face and 50% online, ensuring equal learning opportunities and maintaining engagement with both peers and instructors. This study incorporated digital tools such as Padlet, Google Jamboard, and Nearpod to enhance the students' learning experience.	Survey with 1577 university undergraduate students from four different tracks (health, science, engineering, and humanities) in Saudi Arabia. This study also included semi-structured interviews with 21 students.
Ayub et al. [25]	This pilot study engaged students in learning sessions within the Digital Engagement Kitchen (DEK), which is equipped with hybrid learning facilities and uses tools such as Zoom and Panopto. Panopto was used to record and share class sessions to facilitate synchronous communication and participation between participants. The PTZ cameras installed in the DEK enabled high-quality video capture of practical demonstrations and activities, enhancing the synchronous learning experience for online and F-2-F students.	This study involved two phases: a pre-pilot test with 21 students and a pilot test with 17 students. In the pre-pilot phase, students participated in a survey evaluating the hybrid learning setup in the DEK. In the pilot phase, students experienced a semester of learning in the DEK and completed a survey measuring "Ease of Use", "Functionality", "User Interface", and "Speed".

Table 4. *Cont.*

Study	Pedagogical Aspects Discussed by Authors	Research Method
Butz and Stupnisky [26]	This study applied Deci and Ryan's (1985) self-determination theory in investigating the relationships among students' needs satisfaction, motivation, and achievement in synchronous hybrid learning environments—simultaneously teaching on campus and online through web conferencing.	The sample of this study consisted of 118 unique synchronous hybrid students for survey 1, with 70 attending courses online and 48 attending on-campus. The participants included 72 males and 44 females, ranging in age from 21 to 59 years. In survey 2, the sample included 100 students, with 63 being online students and 37 on-campus students. The participants were studying for master's degrees. Qualitative data were collected via interviews with students (n = 20) and faculty (n = 3).
Butz and Askim-Lovseth [27]	This study investigated the impact of hybrid learning environments on students' motivation and learning outcomes, using active learning and flipped classroom models to enhance student engagement and satisfaction. The longitudinal study of synchronous hybrid business/public administration (BPA) programs explored the role of the achievement of the emotions enjoyment, anxiety, and boredom in the domains of program achievement and technology use.	Participants were students enrolled in synchronous hybrid Masters of Business Administration (MBA), Masters of Public Administration (MPA), or Masters of Aviation (MS-Avit) programs at a large research university in the Midwestern United States. Survey 1 consisted of 118 synchronous hybrid students, and survey 2 consisted of 100 hybrid students.
Cain et al. [30]	This paper studied the use of robotic telepresence in the synchronous hybrid course. Eleven students participated online, and one participated in the classroom. The traditional instructional mode has not been changed; they only introduced new technologies to support student participation. A desktop robot Kubi and telepresence robots (TPRs) were used.	Observations, surveys during the course semester, and focus group interviews after the semester with 12 doctoral students and 3 faculty members in an HE course, documenting their experiences with robotic telepresence.
Capello et al. [31]	This phenomenological study explored a doctoral program that used telepresence robots (TPRs) for distance learning in a synchronous hybrid learning environment.	A survey and focus groups were used to study students' and faculty's perceptions of their learning and teaching and experiences with TPRs in a synchronous hybrid environment. This study included 16 students and 8 faculty participants.
Carruana Martín et al. [32]	The pedagogical approach focusses on collaborative learning flow patterns (CLFPs) that facilitate the orchestration and management of groups in synchronous hybrid learning environments using mobile applications for teachers and students to improve collaboration, communication, and resource sharing.	The testing of the tool, which includes one mobile application for the teacher and another for the student, involved 100 users in a preliminary evaluation, followed by interviews with 10 teachers working in synchronous hybrid learning environments.

Table 4. *Cont.*

Study	Pedagogical Aspects Discussed by Authors	Research Method
Gleason and Greenhow [34]	This study used robot-mediated communication (RMC) to facilitate synchronous classroom discussions in a hybrid doctoral course. The course combined asynchronous online discussions with synchronous sessions using Zoom or robotic technologies (Kubi and double robots). The robots were positioned to simulate a real classroom environment to increase social presence and reduce transactional distance.	Ten online students and one face-to-face student agreed to participate in this study. Data were collected from a survey, focus groups, and students' written reflections.
Hayes and Tucker [36]	This study focused on using synchronous hybrid pedagogy to nurture a community of inquiry (CoI) within a synchronous hybrid teaching environment in a tourism Master's program, emphasizing a supportive and connected learning community.	The study participants included in-class and online students from the Master's of Tourism program. Seven semi-structured interviews were conducted with students and teachers (the exact number of interviewed participants is not specified in the paper).
Nørgård [39]	This study explored the concept of hybrid lifelong learning, focusing on changes in hybrid learning, adaptation of traditional methods, and the creation of new learning experiences.	This study does not mention specific participants or experiments as it is a theoretical study of hybrid lifelong learning.
O'Byrne and Pytash [8]	The described hybrid learning pedagogy combines face-to-face instruction with online instruction, allowing students some control over the path, pace, time, and location of their learning.	This review paper presents discussion on modifying pedagogy across path, pace, time, and place.
Pham and Tran [42]	This study employed a hybrid synchronous teaching method applied due to the COVID-19 pandemic, which integrates the participation of simultaneous and remote students in learning activities.	Thirteen teachers who had no previous experience in hybrid teaching participated in this study. Semi-structured interviews were conducted, allowing for flexible data collection and qualitative thematic analysis.
Raes et al. [43]	This study focused on synchronous hybrid learning. It aimed to summarize the existing evidence in this area. The research specifically examined the benefits of this approach. It also explored the challenges associated with its implementation. Finally, this study reviewed the current design guidelines to support effective hybrid learning.	This review included 47 studies that examined synchronous hybrid learning environments in higher or adult education contexts.

Table 4. *Cont.*

Study	Pedagogical Aspects Discussed by Authors	Research Method
Zydney et al. [47]	A 'Here or There' (HOT) pedagogic approach was used, allowing students to participate simultaneously on campus ('here') and remotely ('there') in real time. This study presents three implementations of HOT instructions: (1) a virtual flipped classroom in which students viewed content asynchronously and engaged synchronously; (2) student-facilitated, where students conducted breakout sessions; and (3) a hybrid that combined both methods.	This study described three cases of HOT instruction at two universities. The virtual flipped classroom and the hybrid approaches each involved up to eight "here" students. The student-facilitated approach used a large collaborative classroom with multiple "pods", but the exact number of participants is not specified.

The authors in [47] discussed how to understand the concepts of hybrid, hybridization, and hybridity to take advantage of the potentials and opportunities these concepts hold when it comes to lifelong learning and how we can apply this understanding to describe hybrid lifelong learning in ways that separate it from emergency teaching and learning, as well as other similar formats such as online learning or parallel teaching. The researchers also synthesized insights from a body of recent research on hybrid education and hybrid learning, reflecting the complexity added by the notion of hybridity to learning, learning environments, and lifelong learning. They also considered a novel conception of hybridity that foregrounds the complexity, entanglement, and dissolution of dichotomies as well as a more integrated and holistic theorization of the assumptions and premises that underpin hybrid learning based on existing theories and research.

Some studies also highlight several gaps in the current understanding and implementation of synchronous hybrid learning environments. Alhusban [24] addresses critical issues in synchronous hybrid learning, focusing on enhancing student engagement through these models. Similarly, Ayub et al. [25] investigates the integration of face-to-face instruction with online activities to improve academic performance and engagement. Other authors [26,27,31] highlight the use of blended learning and flipped classrooms, demonstrating significant improvements in student motivation, engagement, and learning outcomes. Active learning frameworks are central to several studies. For example, Cain et al. [29] and Hayes and Tucker [36] emphasize the importance of active learning models to support both remote and in-person students, enhancing interaction and engagement in hybrid courses. These studies demonstrate the potential of active learning to create more immersive and interactive learning environments. The role of innovative technologies in hybrid learning is explored by Butz and Stupnisky [28], which focuses on the assessment of oral communication skills using blended learning approaches. Some authors [32,34] investigate the integration of social media and digital tools to enhance student engagement and collaborative learning, highlighting the effectiveness of these technologies in creating connected and interactive hybrid learning environments. Nørgård [39] presents a comprehensive analysis of the concept of hybrid pedagogy, providing insight into its theoretical foundations, practical implementations, and outcomes within higher education contexts and declares that theoretical groundwork is provided to circumvent the "common sense" understanding of hybridity in hybrid learning. This groundwork synthesizes insights from recent research, reflecting the complexity added by hybridity to learning environments and lifelong learning. Moreover, it summarizes insights from recent research on hybrid education and learning, highlighting the complexity that the concept of hybridity brings to learning processes. He also identifies a novel conception of hybridity that foregrounds the

complexity, entanglement, and dissolution of dichotomies as well as a more integrated and holistic theorization of the assumptions and premises that underpin hybrid learning based on existing theories and research settings. Their work explores the integration of in-person and online learning environments, examining the synergies between traditional and digital teaching methods. This study identifies the key factors that influence the effectiveness of hybrid pedagogy, including technological infrastructure, instructional design, and academic development. Pham and Tran [42] presented a study investigating teachers' perceptions of synchronous hybrid teaching which has never been implemented in this school before. The results show that the teachers were well prepared before switching to hybrid teaching. Several advantages of hybrid teaching were suggested, including (1) instructional flexibility, (2) optimal learning conditions for on-campus students, and (3) the ability for people to study from home. Raes et al. [43] presented one of the main findings, that existing research suggests cautious optimism about synchronous hybrid learning, which creates a more flexible and engaging learning environment compared to fully online or fully on-site instruction. However, this new learning space has several challenges that are both pedagogical and technological in nature. These studies collectively underscore the critical role of adopting various pedagogical frameworks, such as blended learning, flipped classrooms, and active learning, in hybrid learning environments. Research analysis demonstrates the critical importance of robust pedagogical frameworks for designing effective synchronous hybrid learning environments while also highlighting significant challenges in their implementation. One challenge is that educators often lack specific pedagogies for hybrid formats, despite teaching several courses with remote students. This highlights the need for focused faculty development. Student experiences further illuminate the importance of well-designed frameworks, as hybrid environments offer benefits like increased access but present challenges in managing transitions between interaction modes. Meanwhile, tools such as "Smart Groups" attempt to adapt pedagogical frameworks using features such as collaborative learning flow models, although their effectiveness requires further investigation.

RQ2: *How can we enhance students' engagement in hybrid teaching and learning?*

By effectively integrating hybrid teaching and learning, educators can significantly enhance student engagement, satisfaction, and learning outcomes, demonstrating their potential to create dynamic, interactive, and inclusive educational experiences. Strategies such as collaborative activities, interactive, and multimedia resources are highlighted as effective means of fostering active participation and motivation among students [24,25]. Additionally, providing opportunities for self-directed learning and peer interaction can contribute to a more engaging learning experience.

Table 5 shows a variety of strategies used to increase student participation in hybrid learning environments. These strategies focus on collaborative activities, discussions, multimedia resources, and fostering self-directed learning and peer interaction to encourage active participation and motivation among students. Alhusban [24] and Ayub et al. [25] highlight the importance of collaborative activities and interactive discussions in enhancing student engagement and academic performance in synchronous hybrid learning. They stress that active participation and opportunities for self-directed learning are crucial for maintaining student motivation. In a similar way, Butz et al. [28] and Butz and Stupnisky [27] demonstrate the benefits of interactive discussions and collaborative projects, showing how different tools and peer interaction can improve oral communication skills and encourage active participation through technology-mediated communication. Studies by Cain et al. [30] and Capello et al. [31] point out the use of innovative technologies such as robotic telepresence, augmented reality, and virtual labs to create more engaging

learning experiences. These studies highlight the importance of technology in promoting self-directed learning and peer collaboration. The researchers in [32,34] discuss the role of social media and online tools in supporting student engagement and interaction. They emphasize the value of structured group activities, interactive discussions, and peer feedback to create a collaborative and connected learning environment. Hayes and Tucker [36] focus on building a community of learners through synchronous hybrid pedagogy, using collaborative activities, interactive discussions, and active learning models to foster an inclusive and engaging learning environment. This approach helps cultivate a sense of community and enhance student engagement. Finally, Butz and Askim-Lovseth [26] investigate the assessment of oral communication skills in a synchronous hybrid MBA program, comparing online and face-to-face methods. They underscore the importance of technology-mediated communication in increasing engagement, demonstrating that both domestic and international students benefit from these interactive and engaging assessment methods.

Table 5. Student engagement aspects.

Study	Student Engagement Aspects	Research Instrument
Alhusban [24]	Collaborative activities and interactive discussions addressing critical issues in hybrid learning. Emphasison student engagement through active participation and peer interaction.	- *
Ayub et al. [25]	Use of multimedia resources and blended learning activities to improve student engagement and academic performance. Highlights the importance of interactive content and self-directed learning opportunities.	- *
Butz and Stupnisky [27]	Use of multimedia tools and peer interaction to enhance oral communication skills in a synchronous hybrid MBA program. Encourage active participation through technology-mediated communication.	- *
Butz and Askim-Lovseth [26]	Using Adobe Connect for real-time teaching, providing tailored support for international students, facilitating direct feedback on oral communication skills, and offering flexible learning opportunities in an engaging and supportive environment.	- *
Cain et al. [30]	Robotic remote participation devices were used to give online students a greater presence in the classroom. The communication tool was designed to enable chat and instructor screen sharing.	- *
Capello et al. [31]	The program encouraged social presence, used a cohort model to build community, and implemented residency requirements to establish relationships early.	- *
Carruana Martín et al. [32]	The student app enhances students' learning by integrating with courses, automatically assigning groups, and using Bluetooth sensors for effective classroom management. It provides tools such as chat, multi-device access, and resource sharing to promote organized, secure, and efficient collaboration and communication.	- *

Table 5. *Cont.*

Study	Student Engagement Aspects	Research Instrument
Cohen et al. [33]	Engagement is enhanced through video conferencing, creating a culture of collaboration and reflection, incorporating interactive activities such as educational escape rooms and a flexible learning environment that is adaptable to individual needs.	This study does not mention specific participants or experiments as it is a literature review.
Gleason and Greenhow [34]	Integration of social media and online tools to support student engagement and interaction in hybrid learning environments. Emphasis on interactive discussions and peer feedback.	- *
Hayes and Tucker [36]	Nurturing a community of learners through hybrid synchronous pedagogy. Use of collaborative activities, discussions, and active learning to create an engaging and inclusive learning environment.	- *
Rodríguez et al. [44]	Interactive activities were used to foster a sense of community, emphasizing the presence of a physical instructor and bringing virtual learners together in shared spaces with teaching assistants.	A total of 28 graduate students participated in this study, of which 22 participated in-person and 6 virtually. Of these, nine students participated in focus groups and completed an online survey.
Schumann et al. [45]	Combining traditional and digital methods using innovative tools and providing practical case studies and recommendations for the effective implementation of hybrid learning.	The number of participants is not specified because the focus of the paper is on conceptualizing and modeling hybrid forms of learning and teaching rather than empirical research involving specific numbers of participants.
Subramanian [46]	Pre-session tutorials, small group participation, feedback mechanisms, and reflection exercises were used, as well as hands-on experience in hybrid sessions and alternative resources for distance students.	A total of 221 student reflections were received, and 37 reflections were recorded for traditional hybrid synchronous sessions.

* Information related to the research instrument is already presented in Table 4 and is therefore not repeated here.

Cohen et al. [33] discussed the engagement of a teacher and a student in a class through a videoconference. The teacher is simultaneously "at home" and "in class", as is the student. The teacher must also acknowledge the students' "home" space while simultaneously managing the "classroom" space and their own "home" space. This complex learning environment proved challenging for both teachers and students.

Other authors [44] highlighted how to better sustain hybrid learning experiences: (i) social exchanges between virtual and in-person learners should be maximized; (ii) the instructor should engage with virtual students several times during the course to exchange and provide feedback in-person; and (iii) the various capacities afforded by online platforms to create a shared sense of a learning community should be optimized.

Schumann et al. [45] presented hybrid forms of university teaching that are increasingly combined in different contexts and degrees of digitization. The increasing complexity of

higher education teaching can only be managed through structured, transparent, and evidence-based approaches when designing learning and teaching models. The suggested hybrid teaching reference model describes the combination of several teaching and learning dimensions. It builds a foundation for systematically restructuring university teaching using innovative digital approaches.

These studies collectively underscore the critical role of employing various strategies to enhance students' participation in hybrid learning environments. Incorporating collaborative activities, interactive discussions, tools, and opportunities for self-directed learning and peer interaction is an effective strategy that educators can use to greatly enhance student engagement, motivation, and academic success.

Another key aspect is related to the importance of seamless technological integration in hybrid teaching. This includes the use of learning management systems (LMSs), multimedia tools, and communication platforms to facilitate course delivery, content dissemination, and student interaction. The use of technology can improve accessibility, flexibility, and interactivity in hybrid learning environments.

RQ3: *What is the impact of technological integration on hybrid learning scenarios, both for students and teachers?*

Technology integration, as outlined in Table 6, highlights the key tools and platforms that support hybrid learning environments. The analysis of studies that address aspects of technological integration in hybrid teaching scenarios shows an array of setups and contexts, from the simple use of video conferencing technologies, often combined with an LMS, to the adoption of more sophisticated robotic telepresence devices. Besides the obvious fact that technology is necessary for these scenarios, perceptions of its usability, functionality, and added value to the overall learning process are a concern depending on the degree of investment, the course subject, the pedagogical approaches, and the role of the participant (student or teacher).

Table 6. Technological integration aspects.

Study	Technological Integration Aspects	Research Instrument
Ayub et al. [25]	Cooking course with online students through videoconference: users gave positive feedback on the usability and functionality but had issues with speed and video lagging and occasional lack of sound.	- *
Cain and Bell [29]	The course used robotic telepresence for whole-class communication and video conferencing using Zoom for small-group work. The students found the transition from robotic to telepresence challenging and time-consuming. Although telepresence provided a stronger sense of presence, many preferred the practicality and convenience of video conferencing.	This study involved 15 participants: 10 physically present students, 5 tele present students, 1 instructor, 1 teaching assistant, and 1 technology navigator. Continuous discussion and feedback sessions with the instructor and one-on-one interviews with physically present and remotely participating students during and after the course were used.
Cain et al. [30]	Students preferred robotic telepresence to interact with people present in the room, but to interact with online classmates, they preferred video conferencing.	- *

Table 6. *Cont.*

Study	Technological Integration Aspects	Research Instrument
Capello et al. [31]	Students and faculty agree that the use of telepresence robots adds richness and diversity, and they are willing to tolerate learning disruptions due to technology. The teachers had problems with technology, but they adapted some of their strategies.	- *
Carruana Martín et al. [32]	Introduction of Smart Group applications—75% score on the usability questionnaire; almost all features were perceived as useful according to Technology Acceptance Model (TAM) interviews. This study needs further iterations.	- *
Gleason and Greenhow [34]	Students felt that robot-mediated communication helped them feel closer to other students and was an improvement to video-mediated communication. The limitations were a narrow field of vision and difficulty in hearing robots that were further away.	- *
Okoye et al. [41]	This study assumed that the HEIs had support from an LMS and learning complements with MOOCs (edX and Coursera). The main (macro) conclusion is that HEIs adapted their teaching and learning processes and increased the use of remote technology and e-contents.	Statistical analysis of datasets/analytics from MOOCs (edX: 11,691 samples and Coursera: 66,859) and Emotions Experience Survey (3869 students + 925 teachers) from several universities.
Raes [43]	The use of the camera is important for remote students (to see their colleagues and teacher), as well as for the teacher (to evaluate remote students' reactions); social interaction was found to be limited compared to auditorium class.	Semi-structured interviews for teachers (3 teachers) and pre- and post-test for students (45 third-year bachelor students from the Faculty of Medicine at KU Leuven, as well as 113 bachelor students from the Faculty of Law).
Subramanian [46]	Technological integration included online synchronous and asynchronous training using platforms such as Zoom for remote clinics. This gives students greater flexibility and global interaction but can lead to engagement difficulties and technology disruptions. For teachers, this requires adaptation of teaching methods, increased workload, and being technology savvy.	- **

* Information related to the research instrument is already presented in Table 4 and is therefore not repeated here. ** Information related to the research instrument is already presented in Table 5 and is therefore not repeated here.

Some of the studies [30,31,34] evaluate the use of telepresence robots, with generally good results, as the type of interaction is viewed as an added value to collaborative class work. However, social interaction among remote students was found to be more limited, as these devices are designed for classroom activities [34]. An aspect worth mentioning is robustness and the increased tolerance of the user to occasional disruptions due to technical failures [31]. As these setups offer more opportunities for engagement, a problem with

video or Internet connection is viewed as less critical compared to more traditional video conferencing solutions [25]. Moreover, Cain and Bell [29] presented a case study which describes how we used a mix of robots and other modes of telepresence to help remote students enrolled in an on-campus doctoral-level course and to stay connected with both people and content during synchronous hybrid class sessions.

The teacher's experience in technological integration is highly dependent on their willingness to innovate and adapt pedagogical approaches. Most are used to interact with video conferencing tools, due to the COVID-19 pandemic, and many did not adapt their strategies, as they feel that remote students can benefit from the class the same way as their peers in the classroom [31]. However, these articles emphasize that many teachers and institutions are using the opportunity to integrate more technology into their practices [32], even creating pedagogical models to embrace it [41].

Subramanian [45], by using hybrid learning, suggested that students may feel that on-campus students are given preferential treatment. Students may also have poor access to technology and face technology disruptions, which could hamper their learning experience. However, other research, as evidenced in these papers, shows that the impact of integrating new technologies in hybrid scenarios is greater if driven by pedagogical principles [30,41,43], with motivated teachers willing to innovate and adapt teaching practices.

RQ4: *How do training and support measures influence the willingness and ability of university teachers to implement hybrid teaching formats?*

Academic development emerges as a critical aspect of successful hybrid teaching initiatives (see Table 7). Training and support for instructors in instructional design, technological tools, and pedagogical strategies are essential to ensure the effective implementation of hybrid courses. Additionally, addressing faculty concerns related to workload, technical proficiency, and assessment practices can promote faculty involvement and participation.

Table 7. Academic development aspects.

Study	Academic Development Aspects	Research Instrument
Alhusban [24]	Training teachers in the use of digital resources and adapting their methods for virtual classes was crucial for the success of the educational model.	- *
Butz et al. [28]	Faculty members identified technology influence as a key factor impacting the learning experience. This emphasizes the need for educators to possess various competencies, technical solutions, and organizational support. Teachers' familiarity with technology and its possible influence on students' emotional states are important.	Data were collected using self-reported information from students (218 participants).
Capello et al. [31]	Educators wanted professional learning opportunities to increase their knowledge and respond to the needs of distance learning, emphasizing the importance of ongoing support and development for staff in this environment.	- *

Table 7. *Cont.*

Study	Academic Development Aspects	Research Instrument
Gleason and Greenhow [34]	Educators require skills in integrating technology into teaching practices, adapting to evolving systems, and utilizing data from technology-mediated courses for future improvements.	- *
Schumann et al. [45]	Educators require skills in integrating digital tools, adapting pedagogical strategies, and managing hybrid learning environments.	- **
Subramanian [46]	From educators' perspectives, transitioning to hybrid learning required significant adjustments, including proficiency with technology, managing increased workloads, and ensuring educational standards. It also highlighted the need for support, training, and effective communication to engage remote students and reduce their feelings of exclusion.	- **
Ulla and Perales [4]	Teachers found that hybrid teaching requires strong pedagogical skills and familiarity with online platforms. Managing online and on-site students adds complexity to hybrid learning.	This study included 35 first-year students, 12 of whom attended on-site and 23 online, and one teacher, who reflected on his hybrid teaching experience.

* Information related to the research instrument is already presented in Table 4 and is therefore not repeated here. ** Information related to the research instrument is already presented in Table 5 and is therefore not repeated here.

Alhusban [24] emphasizes the crucial role of teacher training in the use of digital resources and adapting their teaching methods to virtual classes. This study, conducted through surveys and semi-structured interviews with 1577 participants, demonstrates that such training initiatives are essential for the success of the educational model. This study shows the need for universities to provide extensive support and resources to facilitate the introduction and sustainable implementation of hybrid teaching formats. This includes both technical infrastructure and educational training to ensure that instructors are not only willing but also able to effectively design hybrid teaching and learning environments. The importance of targeted training programs to effectively support the implementation of hybrid courses is evident in this paper.

The study conducted by Butz et al. [28] emphasizes the importance of teachers' digital competencies, access to technical solutions, and adequate organizational support. Based on self-reported data from 218 students, the research suggests that a teacher's familiarity with technology, as well as its impact on students' emotional states, is crucial. Additionally, the authors discuss teaching and learning in hybrid environments, technology-mediated assessment design, and accreditation practices in the delivery of non-traditional programs.

Capello et al. [31] highlight the need for professional learning opportunities to expand knowledge and respond to the demands of distance learning. The findings of surveys and focus groups with 16 participants emphasize the importance of ongoing support and development for teaching staff in digital learning environments.

In addition, Gleason and Greenhow [34] explore the skills educators need to integrate technology into their teaching practices, adapt to evolving systems, and use data from technology-mediated courses for future improvements. This study involved ten online students and one in-person student, all of whom participated in a post-semester survey.

Schumann et al. [45] identified that teaching in a hybrid format presents both challenges and opportunities, and, compared to in-person teaching, requires educators to develop a complementary set of skills.

Ulla and Perales [4] stated that teachers who embark on hybrid teaching should consider their teaching and learning materials to determine whether they support the learning needs of their students so that student participation and active participation in hybrid classroom instruction are ensured.

The analyzed studies highlight the importance of providing targeted training and support measures to improve university teachers' readiness and capability to implement hybrid teaching. The studies reveal that such measures not only strengthen the technical expertise of teachers but also increase their engagement and satisfaction by addressing the emotional and pedagogical challenges of hybrid instruction. This suggests that comprehensive support covering both technical and pedagogical aspects is critical to enable effective and engaging hybrid learning experiences.

However, teachers' access to resources and technical solutions for hybrid education is significantly influenced by different national policies. In the European context, for instance, the "no-use" policy for software hosted outside the EU or noncompliant with the European general data protection regulations (GDPRs) has posed substantial hurdles for educators in leveraging digital tools effectively. Consequently, educators have faced interruptions in the education service or the adoption of suboptimal solutions. To address these challenges, policy implications suggest the need to promote experiential learning and provide a space for students and teachers to try new technologies as they emerge. In addition, policies should focus on guiding the design of professional development and leadership training that supports educators in dealing with uncertainty while using digital technologies. These policy considerations highlight the critical role that governance frameworks play in shaping teachers' access to and use of resources in hybrid education settings [49].

RQ5: *How do formative assessment and feedback methods in hybrid learning environments enable teachers to effectively monitor student progress and provide tailored support?*

Another important aspect of hybrid learning is the role of assessment and feedback in promoting student success. The effectiveness of formative assessment and feedback methods in hybrid learning environments depends on several interrelated factors. These methods, crucial to monitoring student progress and providing tailored support, are enabled by technological advances, such as adaptive learning platforms that offer personalized learning experiences and automated assessments. However, the effective implementation of formative assessments requires significant organizational support, including resources to redesign courses and address increased teacher workloads. As a result, investments are needed in a variety of areas, including professional development, technology infrastructure, support staff, and initiatives to bridge the digital divide [50].

The effective implementation of hybrid learning requires comprehensive training and support from multiple stakeholders. Faculty members are the primary group that require extensive professional development to ensure competence in both the pedagogical and technological aspects of hybrid teaching. They need training to effectively use digital tools, manage simultaneous face-to-face and online student groups, and adapt their teaching methods. IT support staff also play a crucial role and need training to provide technical assistance during asynchronous and synchronous online classes. Students need guidance on using digital platforms, developing self-directed learning skills, and improving digital literacy. Those with lower language proficiency may need additional support. Administrative personnel involved in the organization of hybrid programs need training in managing the technological infrastructure and understanding the unique needs of online and face-to-face

learners. Finally, institutional leaders must be educated about the benefits, challenges, and resource requirements of hybrid learning to make informed decisions. Finally, the successful implementation of formative assessment methods in hybrid learning environments also depends on a comprehensive approach that addresses technological, organizational, and pedagogical challenges while providing ongoing support and training to educators.

Implementing a variety of assessment methods such as quizzes, online discussions, peer reviewed assignments, and project-based assessments allows instructors to fully monitor student progress and offer personalized support tailored to individual learning needs. These diverse approaches accommodate different learning styles and provide a more comprehensive picture of student performance. In addition, the use of technology for automated assessment, peer assessments, and multimedia feedback, such as video or audio comments, can significantly increase the efficiency of assessment processes and improve the quality and speed of feedback. This technology integration not only saves instructors time but also ensures that students receive meaningful and timely feedback to support their academic growth both in person and online.

The assessment and feedback in Table 8 highlight the importance of implementing a variety of assessment strategies in hybrid learning environments. Alhusban [24] discovered that students responded overwhelmingly positively to receiving feedback, guidance, and equitable treatment across instructional modes. This suggests that formative assessment and feedback can be effective in hybrid environments if teachers are properly trained to use digital tools. This training allows them to provide consistent feedback and instruction and ensure that all students, whether online or face-to-face, receive equal attention and support.

Table 8. Assessment and feedback aspects.

Study	Assessment and Feedback Aspects	Research Instrument
Alhusban [24]	Training teachers in the use of digital resources and adapting their methods for virtual classes was crucial to the success of the educational model. The learners were mostly positive about receiving feedback, receiving instructions, and being treated equally regardless of the teaching mode.	- *
Ayub et al. [25]	The tendency of learners to procrastinate submitting assignments is significantly reduced when clear and well-defined deadlines are provided within the learning platform.	- *
Carruana Martín et al. [32]	The authors discuss the facilitation of group tasks in hybrid synchronous learning environments by enabling teachers to create, manage, and modify groups dynamically, ensuring effective collaboration among students attending face-to-face or online.	- *

* Information related to the research instrument is already presented in Table 4 and is therefore not repeated here.

The researchers in [25] focused on the behavioral aspect of learning and found that learners' tendencies to procrastinate submitting assignments is reduced when instructors set clear goals and deadlines through the learning platform. This suggests the effectiveness of structured formative assessment in hybrid learning environments. This supports the suggestion that clear requirements and time constraints encourage students to manage their time better and stay engaged with the course. It also allows instructors to track submissions and progress more efficiently and provide timely feedback and support.

Carruana Martín et al. [32] discuss the facilitation of group assignments in synchronous hybrid learning environments, emphasizing the ability of instructors to dynamically create, manage, and modify groups. This capability ensures effective collaboration between students, whether they are participating in-person or online. Such dynamic group management can also serve as a formative assessment tool, enabling teachers to monitor student interaction and collaboration, adjust groups as needed to optimize learning outcomes, and provide targeted support to address specific group dynamics and individual needs.

From these studies, the following conclusions can be drawn about formative assessment and feedback in hybrid learning environments. Collectively, these studies highlight the importance of integrating robust digital tools, structured assessment strategies, and flexible teaching methods. Implementing structured formative assessments with clear requirements and deadlines can significantly increase student engagement and reduce procrastination, allowing teachers to better monitor progress and intervene when necessary [25]. Teachers' ability to dynamically manage and adapt groups in a hybrid environment [32] supports effective collaboration and interaction among students, which is critical for monitoring student progress and providing feedback that addresses specific group dynamics and individual needs. The effective monitoring of student progress and targeted support in hybrid environments [24] is highly dependent on teacher training in digital tools and adaptive teaching methods.

Although these studies have provided valuable information on the use of formative assessment and feedback in hybrid learning environments, a comprehensive evaluation of the effectiveness of these methods is currently lacking. Further analysis of the effectiveness of specific formative assessment methods, such as exams, assignments, papers, and presentations of project results, would be beneficial. Such an in-depth analysis would help to optimize pedagogical practice in hybrid learning settings in a more targeted way, enabling the more effective adaptation of teaching methods to the needs of students.

RQ6: *How does the implementation of hybrid learning affect student learning outcomes?*

The sixth key aspect is related to the evaluation of students' learning outcomes, which is a key focus of research in hybrid teaching and learning. By comparing outcomes between hybrid and traditional courses, researchers seek to identify the best practices and factors that influence the effectiveness of hybrid pedagogies.

Numerous studies indicate that hybrid learning can positively impact student learning outcomes. By combining online flexibility with in-person engagement, students can access a variety of resources and experiences tailored to their needs, fostering deeper understanding and motivation. Also important is the quick and timely feedback from online assessments, which facilitates self-monitoring and skill development. A variety of methodologies and instruments can be used for the assessment of student learning outcomes (see Table 9).

Table 9. Aspects on evaluating students' learning outcomes.

Study	Aspects on Evaluating Students' Learning Outcomes	Research Instrument
Alhusban [24]	Assessing learners' satisfaction, motivation, attention, and success through a mixed methods approach.	- *
Butz et al. [28]	The students provided their perceptions of control, value, enjoyment, anxiety, and boredom, which were then used to assess their program achievement and successful technology use.	- **

Table 9. *Cont.*

Study	Aspects on Evaluating Students' Learning Outcomes	Research Instrument
Capello et al. [31]	This study focused on qualitative evaluation using phenomenological methods to explore and understand the experiences and perceptions of both students and faculty participating in a doctoral program that used telepresence robots.	- *
Han et al. [35]	This study focused on qualitative aspects such as student satisfaction, flexibility, participation, and equity in the context of a HyFlex learning environment.	Qualitative data collection through classroom observations and interviews (18 participants).
Li et al. [37]	A survey was conducted to gather insights and new understandings from both teachers and students about the implementation of the hybrid learning model, participants' experiences, and perceptions of adapted teaching and learning methods during the pandemic.	Questionnaire survey for teachers and students (76 teachers and 162 students).
Lohiniva and Isomöttönen [38]	This study focused on qualitative interviews to gather data on students' perceptions of motivation and the impact of the COVID-19 pandemic.	Semi-structured interviews and the content analysis (11 participants).
Nykvist et al. [40]	The performance type was a qualitative case study focusing on exploring the effectiveness of a cross-campus or university collaboration program in music, communication, and technology (MCT) education.	Semi-structured interviews with educators and students (6 educators and 3 students).
Okoye et al. [41]	This study analyzed MOOC data, course grades, and emotional responses to measure learning outcomes.	- ***
Raes [43]	This study involved pre- and post-tests for conceptual understanding and surveys for assessing affective engagement.	- ***

* Information related to the research instrument is already presented in Table 4 and is therefore not repeated here. ** Information related to the research instrument is already presented in Table 7 and is therefore not repeated here. *** Information related to the research instrument is already presented in Table 6 and is therefore not repeated here.

A study by Alhusban [24] used a mixed methods approach to evaluate the learning outcomes of a synchronous hybrid learning method (SHLM). This approach included both quantitative survey data and qualitative insights from semi-structured interviews. This evaluation provided a comprehensive understanding of the impact of the SHLM on learner satisfaction, motivation, attention, and overall success in the learning environment. Consequently, the type of assessment of learning outcomes used in this study was multifaceted and included direct feedback from students about their experience and the effectiveness of the learning model in relation to their educational needs. The results showed that the hybrid synchronous learning approach generally led to positive learning outcomes, which were reflected in general learner satisfaction. Students appreciated the equal opportunities for home and face-to-face learning, enhanced using digital tools such as Padlet, Google Jamboard, and Nearpod. However, the effectiveness of the SHLM varied between stu-

dents, particularly between beginners and advanced learners, who sometimes struggled to understand online lessons due to their level of skill.

Butz et al. [28] point out that the evaluation of learning outcomes showed that students' emotions played a significant role in their academic achievement in synchronous hybrid learning environments. This study found out that enjoyment and perceived success were positively correlated, while anxiety and boredom were negatively correlated with perceived success. This suggests that managing students' emotional experiences, particularly by reducing anxiety and boredom, can improve their learning outcomes.

The study conducted by Capello et al. [31] shows that the overall progression of students remained relatively positive, with both face-to-face and distance learners demonstrating resilience and adaptability, indicating a promising trajectory despite the learning obstacles. The hybrid learning model facilitated the interaction and engagement of both face-to-face and distance learners, which is critical to creating a cohesive learning community. However, frequent technical problems disrupted learning and teachers initially struggled with the telepresence technology, which affected effective teaching strategies. This highlights the importance of reliable technology and teacher preparation for the success of hybrid learning.

Han et al. [35] conclude that hybrid learning, particularly the HyFlex model, had a positive impact on students' learning outcomes by providing flexibility to meet the diverse needs of students. This flexibility improved participation and increased student engagement and interaction with peers and teachers.

The implementation of hybrid learning at the Hong Kong Academy of Performing Arts impacted learning outcomes by requiring the transition to online learning platforms and the introduction of innovative teaching methods such as the flipped classroom and outcome-based learning. This method facilitated students' cognitive participation and reflective learning processes. The survey results showed that both teachers and students adapted to the model and gained new insights, suggesting a positive impact on learning outcomes given the restrictions caused by the COVID-19 pandemic [37].

Lohiniva and Isomöttönen [38] identified several challenges that indirectly affected student learning outcomes. Hybrid learning implemented during the COVID-19 pandemic was problematic in terms of communication, collaboration, and connectivity, which are essential components of an effective learning environment. These challenges may have affected learning outcomes by preventing students from fully engaging with the course content and each other.

The hybrid learning approach explored by Nykvist et al. [40] focusses on delivering flexible learning outcomes by prioritizing flexibility, trust, and the human element alongside ownership. These factors contribute to the creation of a supportive learning experience that can adapt to the changing needs of students, thereby positively influencing student learning outcomes. In addition, the integration of the pedagogy, space, and technology framework ensures the delivery of responsive, student-centered learning experiences, further enhancing overall student achievement.

The results of this study [41] showed that a model combining virtual and face-to-face education was effective in supporting the educational process despite the disruptions caused by the pandemic. Using MOOC data and the Emotions and Experiences Survey questionnaire, it was possible to analyze the teaching and learning experience in detail, showing that the model helped to manage and increase energy levels and motivation to learn for both teachers and students. The authors argue that the HL model had a positive impact on student learning outcomes by ensuring that educational activities could continue effectively in challenging times. Meanwhile, Raes [43] found no significant differences in conceptual understanding between physically present and remote students

but noted that face-to-face students demonstrated greater emotional engagement compared to remote students. This suggests that the implementation of hybrid learning, especially the interaction aspect, plays a crucial role in enhancing student engagement, although it does not necessarily affect the direct acquisition of conceptual knowledge.

Moreover, the systematic review provided by Raes at al. [2] systematizes 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 setup synchronous hybrid learning. One of the main findings is that existing research suggests cautious optimism about synchronous hybrid learning, which creates a more flexible and engaging learning environment compared to fully online or fully on-site instruction. However, this learning space has several challenges that are both pedagogical and technological in nature.

The abovementioned papers show valuable insights into the theoretical frameworks, practical strategies, and empirical evidence surrounding hybrid teaching and learning in higher education. They highlight the opportunities and challenges associated with integrating face-to-face instruction with online technologies, emphasizing the need for pedagogical innovation and ongoing faculty support in this rapidly evolving educational landscape.

4. Conclusions

This study identifies several key factors necessary for the successful implementation of hybrid learning. These include strong technology integration, innovative pedagogical strategies, strong academic development and support, active student engagement, effective assessment practices, and positive learning outcomes. This review highlights the need for a robust infrastructure to meet the technological needs of hybrid learning, ongoing professional development for educators to adapt to new teaching methods, and adaptive pedagogical strategies to meet the diverse needs of students. Furthermore, the importance of formative evaluation and timely feedback is emphasized as essential to improve the learning experience in hybrid environments.

In line with the studies presented above and according to RQ1, we may identify that hybrid teaching and learning is focused on common pedagogical models such as blended learning, flipped classrooms, and active learning, which are frequently cited as effective approaches in these hybrid settings. Moreover, according to RQ2, we identify effectiveness of students' engagement in hybrid teaching and learning, i.e., using strategies such as collaborative activities, interactive discussions, and multimedia resources is highlighted as an effective means of fostering active participation and motivation among students. Additionally, providing opportunities for self-directed learning and peer interaction can contribute to a more engaging learning experience. An important factor that is often overlooked is the development of peer relationships between online and on-campus students. Research has shown that students tend to form stronger connections with peers within the same attendance order but feel less able to develop relationships across multiple modes. This suggests that more intentional efforts are needed to encourage diverse peer engagement. According to RQ3, we identify the importance of the impact of technological integration on hybrid learning scenarios, both for students and teachers, that shows an array of setups and contexts, from the simple use of video conferencing technologies, often combined with an LMS, to the adoption of more sophisticated robotic telepresence devices. Regarding RQ4, training and support measures influencing the willingness and ability of university teachers to implement hybrid teaching formats based on the teacher's experience and support of instructors in instructional design, technological tools, and pedagogical strategies is essential to ensure the effective implementation of hybrid courses. According to RQ5, we analyzed

whether formative assessment and feedback methods in hybrid learning environments enable teachers to effectively monitor student progress and provide tailored support and focus on implementing a variety of assessment methods such as quizzes, online discussions, peer reviewed assignments, and project-based assessments, allowing instructors to fully monitor student progress and offer personalized support tailored to individual learning needs. In relation to RQ6, we analyzed the implementation of hybrid learning affecting student learning outcomes. Numerous studies indicate that hybrid learning can positively impact student learning outcomes. By combining online flexibility with in-person engagement, students can access a variety of resources and experiences tailored to their needs, fostering deeper understanding and motivation.

To strengthen the implementation and effectiveness of hybrid learning, it is essential to allocate significant funds to the creation and maintenance of a robust technological infrastructure, as well as to mandate continuous professional development programs for teachers. This dual approach ensures that both students and teachers have reliable access to the necessary tools and platforms and that educators have the skills and knowledge needed to deliver effective hybrid teaching. Taking into account the needs for professional and technological development, this recommendation aims to create effective blended learning environments that improve learning outcomes and ensure equal opportunities for all students.

While hybrid learning scenarios demonstrate potential through a variety of technological integrations, from basic video conferencing to advanced remote participation devices, both their successes and limitations still need to be critically assessed. Teaching methods must be clearly linked to measurable outcomes, such as student engagement, competencies, and achievement, while addressing the challenges encountered during implementation. Training and support for instructors are essential, but often insufficient, without ongoing resources and practical application guidance, which highlights the gap between theoretical preparation and the reality of the classroom. In addition, formative assessment methods, while diverse, need to be carefully vetted to ensure that they effectively meet individual learning needs without creating barriers such as digital fatigue or unequal access. Furthermore, lessons need to be learnt from emergency transitions, such as those during the COVID-19 pandemic, where issues such as technological barriers and infrastructure limitations became apparent. Many students struggled with limited Internet access and lack of suitable devices for remote learning. Faculty preparation was another significant challenge, as many instructors had to quickly adapt to online teaching methods without adequate training. The transition was particularly difficult in practical hands-on disciplines, where the move to an online or hybrid mode has posed unique challenges in maintaining the quality of teaching. Student engagement and social isolation emerged as another issue, as many learners faced difficulties in forming authentic peer relationships in a virtual environment. Assessment practices also needed to be urgently reassessed to ensure fairness and reliability in a variety of ways. Therefore, addressing these gaps is important to create more effective blended teaching and learning practices, resulting in improved educational experiences for both students and educators.

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