Review of Empirical Studies on Educational Video Conferencing: Scoping Portability and Student Engagement

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Abstract: This systematic literature review explores empirical studies on video conferencing systems (VCS) in higher education, focusing on their pedagogical integration, portability, and ability to support student engagement across diverse disciplinary contexts. Prompted by the widespread shift to online and hybrid teaching during the COVID-19 pandemic, this review critically examines how VCS have been adopted to sustain teaching and learning practices, especially within the framework of signature pedagogies. The review is guided by the PACT (People, Activities, Context, Technologies) framework and follows PRISMA guidelines for identifying, screening, and analyzing relevant literature. A comprehensive search across scholarly databases yielded 414 initial results, from which 32 peer-reviewed empirical studies published between 2020 and 2024 were retained based on strict inclusion criteria. The review reveals three primary trends: (1) a significant lack of attention to didactic design or contextual detail in many studies; (2) a diversity of use cases across disciplines and roles, ranging from lecture delivery and supervision to lab work, group activities, and hands-on learning; and (3) the use of tools integrated with or alongside VCS to support engagement, such as chat functions, quizzes, and collaborative platforms. While platforms such as Zoom, Webex, Google Meet, and Microsoft Teams dominated the reviewed literature, their adoption varied based on institutional capacity, user preferences, and infrastructure. Several studies reported students' reluctance to use webcams due to privacy and comfort concerns, and few adopted additional hardware and software explicitly for enhancing engagement. Despite these constraints, some cases demonstrated innovative practices, including gamified learning, synchronous Q&A, and adaptive video-based labs. The findings indicate that while video conferencing systems have become essential tools for educational continuity, their effectiveness depends on thoughtful pedagogical integration, user competency, additional hardware and software integration, and contextual alignment. The insights from th review aim to inform educators, technologists, and policymakers on improving the use of VCS in education, particularly for developing portable, inclusive, and pedagogically sound digital learning environments.

Keywords: Signature pedagogy, Videoconferencing, higher education, PACT framework

1. Introduction

The experience of teaching in online and hybrid spaces during the COVID-19 pandemic has reshaped the roles of educators and administrators in higher education, highlighting both the potential and the challenges of using video conferencing systems. Teaching methods and classroom environments vary significantly across disciplines, where distinct approaches known as signature pedagogies (Shulman, 2005) define instructional practices. For example, lecture-based teaching in large auditoriums, studio-based design instruction, and Socratic dialogue in law classrooms each present unique spatial and pedagogical configurations. The integration of video conferencing technologies across such diverse formats necessitates a deeper understanding of how these systems can support, adapt to, or disrupt disciplinary teaching models.

Educators' teaching preferences and students' learning styles differ substantially between online and in-person contexts (Abell et al., 2016), and designing engaging online experiences requires new sets of skills and knowledge. As educators were increasingly required to teach fully or partially from home, institutions sought to equip them with digital accessories, software tools, and other resources to compensate for the loss of physical classroom infrastructure. However, reduced visual cues, limited interaction opportunities, unfamiliar online norms, and low technological proficiency have negatively impacted student engagement and diminished the quality of online contact hours.

Although previous empirical and review studies on video conferencing systems (Al-Samarraie, 2019; Hedestig & Kaptelinin, 2005; Khalid & Hossan, 2016; Neustaedter et al., 2020; Weitze et al., 2013) explored collaborative online learning, there remains a pressing need to understand the current demand for portable, discipline-sensitive solutions that approximate the richness of face-to-face interaction. In this light, a systematic literature

review is required to map the empirical evidence on how video conferencing technologies are being used to support student engagement, and to examine whether these tools meet the pedagogical needs of various higher education contexts.

1.1 Research Scope and Desired Contribution

Within the framework of PACT (People, Activity, Context, Technologies), limited research has addressed how teacher and student competencies intersect with the implementation of signature pedagogies in video conferencing environments. While existing literature recognizes the importance of each PACT element in online education, there is a lack of comprehensive analysis of how these dimensions influence the effective use of video conferencing platforms in delivering discipline-specific teaching practices. A deeper understanding of how educators and students navigate their roles and interactions in online, VCS-mediated contexts is essential for optimizing learning outcomes.

The objective of this study is to conduct a state-of-the-art review that identifies contextual challenges, explores innovation opportunities, and outlines key elements for developing a competence matrix. Using a design thinking lens, the review investigates diverse user demographics in higher education, requirements for portable VCS solutions, and contextual factors influencing the design and implementation of these technologies. It also examines the effectiveness of various tools employed to enhance student engagement in online learning. The insights and recommendations aim to support educators, researchers, e-learning consultants, IT staff, teacher trainers, students, and higher education policy-makers in making informed decisions and fostering innovation in digital learning environments.

1.2 Research Questions and Hypotheses

This review is guided by the following research questions: (1) What empirical evidence exists on the use of video conferencing systems in higher education to support student engagement? (2) How do these technologies accommodate different teaching environments and signature pedagogies across disciplines? (3) What are the technological and pedagogical features that enable or hinder portability and engagement in online or hybrid settings?

The review is based on the hypothesis that portable video conferencing systems, when appropriately integrated with pedagogical strategies, can enhance student engagement and support varied instructional models in higher education. However, the extent and effectiveness of such integration likely vary depending on discipline, context, and technological readiness.

1.3 Structure of the Paper

The remainder of this paper is structured as follows: Section 2 outlines the methodology used for conducting the systematic literature review, including selection criteria, data sources, and analysis techniques. Section 3 presents the findings from the reviewed literature, categorized by themes such as student engagement, system features, portability, and discipline-specific applications. Section 4 discusses the implications of these findings for practice, policy, and future research. Section 5 concludes the review by summarizing key insights and offering recommendations for educational institutions and developers of video conferencing tools.

2. Methods

This study applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Moher et al., 2009), which includes four phases: identification, screening, eligibility, and included (See Fig. 1.).

In conducting the systematic literature review, a set of keywords and their synonyms were identified across six thematic categories: Education, Video Conferencing, Online Application, Portable, Engagement, and Learning Experience Design. For example, terms such as school, learning, university, and teaching were used under Education; virtual conference, hybrid, online conference, and specific platforms like Zoom, Teams, Google Meet/Hangout under Video Conferencing; and software, platform, system for Online Application. Keywords like mobile and remote represented Portable aspects, while interaction, communication, and discussion reflected Engagement. Finally, Learning Experience Design included terms like learning environment and flipped classroom. These keywords were systematically combined in various ways to execute multiple database searches, ensuring comprehensive coverage of the literature relevant to video conferencing technologies in higher education.

Multiple keyword combinations were searched through the Technical University of Denmark (DTU) library's integrated scholarly database search tool "DTU Find It." Initial searches yielded 414 matches for papers published since 2018, limited to online or print materials without year restrictions. Google Scholar was employed for the result comparison. Later, nine additional articles were identified during a later search for a screening iteration as the synthesis writing was being finalized after more than one year after the initial search. Initial title and abstract screening focused on "video conferencing systems" within educational contexts, examining user experiences in teaching and learning environments, and various design factors in system and pedagogical implementation. This screening process resulted in 39 articles after excluding studies that did not address the design and experience of video conferencing systems in educational contexts. Full-text screening applied the PACT framework (Benyon, 2019) to identify specifications of people, activities, context, and technologies in video conferencing systems for teaching situations. Following full-text assessment, 32 articles were included in qualitative synthesis.

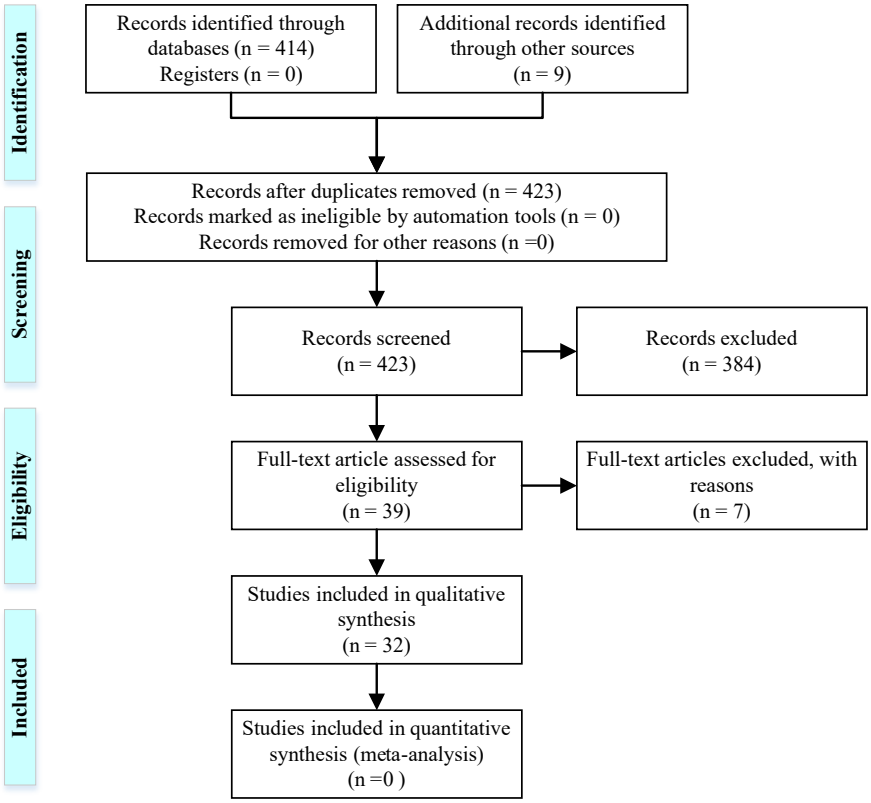

Figure 1. PRISMA flow diagram

This review was limited to peer-reviewed sources, including journal articles, conference proceedings, and book chapters. The scope was further constrained to publications from the past five years (2020 onward) to ensure contemporary relevance. Only articles published in English were considered. Systematic reviews were excluded, with the focus placed exclusively on empirical studies reporting original data and analysis.

Studies were excluded if they: (1) lacked empirical data or relied solely on theoretical frameworks; (2) provided insufficient methodological detail regarding data collection and analysis; (3) did not primarily address online meetings or classrooms; (4) failed to examine the use, impact, or implications of video-conferencing in educational settings; (5) focused on unrelated topics with only marginal relevance to video-conferencing-supported learning; (6) originated from non-peer-reviewed sources lacking methodological rigor; (7) were conducted in non-academic contexts without direct educational relevance; (8) focused exclusively on traditional in-person environments without online comparison; (9) addressed only technological specifications without broader pedagogical or contextual analysis; (10) lacked sufficient relevance to the review objectives of educational video conferencing.

The analysis and synthesis were conducted by applying the PACT framework (Benyon, 2019), extracting the People, Activities, Context, and Technologies and ProPhet (Problem, Phenomenon of Interest, Time) (Booth et al., 2016). The analysis was not conducted for synthesizing experimental or intervention research by applying

methods like PICO (Population, Intervention, Comparison, Outcomes), SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research Type), SPICE (Setting, Perspective, Intervention/Interest, Comparison, Evaluation). PACT recognizes that technology enables task completion within specific settings, and that changes in technology can influence the nature of these activities (Benyon, 2019). To ensure consistency in coding, periodic meetings were held to resolve disagreements through collaborative discussion.

3. Analysis and Synthesis

The empirical studies on video conferencing technology-mediated teaching are categorized and summarized in four sub-sections. In addition, a fifth category synthesizes the review on various additional software used.

3.1 Context of Education and Didactic Design

Out of the 32 papers, six papers have no didactical design context, nine papers present a general perspectives on educational programs and their institutions (organizational context), and 10 papers' contains didactical design or context. These categories and their papers will be presented in the following section.

3.1.1 Lack of Information on Didactic Design or Context

Didactic design, or instructional design, refers to the structured development of educational materials, activities, and assessments to achieve defined learning objectives. Models such as ADDIE (Analysis, Design, Development, Implementation, and Evaluation) guide this process to ensure instructional effectiveness. Despite its critical role in shaping technology use, user experience, and learning outcomes, most of the reviewed studies lacked detailed accounts of the educational context or didactic design underpinning VCS implementation. Several studies did not include specific instructional cases.

Akiyama, Masuda, and Yamaoka (2021) addresses the institutional transition to remote education during the COVID-19 pandemic through the deployment of Cisco WebEx Education Offer at a Japanese university. They highlighted the integration of video conferencing with existing learning management systems to maintain educational continuity. Key functionalities of WebEx—such as real-time communication and screen sharing—were central to facilitating virtual lectures and meetings. The research context underscores the importance of institutional preparedness, technical support, and user training in implementing remote learning infrastructure.

The study by Cavus and Sekyere-Asiedu (2021) aimed to evaluate the suitability of various online video conferencing platforms for educational purposes during the COVID-19 pandemic. Conducted between March and May 2021, the research employed a comparative analysis of seven platforms—Google Meet, Microsoft Teams, GoToMeeting, Cisco WebEx Meetings, Zoom Meetings, ClickMeetings, and BigBlueButton—focusing on features such as participant capacity, recording duration, security, chat and screen sharing capabilities, meeting duration, archival options, trial versions, account requirements, and mobility. The researchers independently accessed each platform, examined their features, and collated the data for comparison. The study did not involve direct participation from users but rather analyzed the platforms' functionalities to inform educators and institutions. Findings indicated that each platform offered distinct advantages and limitations, emphasizing the importance of selecting tools that align with specific educational needs and contexts.

Vashisht and Gautam (2020) examine the limitations of existing video conferencing platforms in capturing and analyzing student engagement during synchronous online education. Based on an April 2020 survey of 256 higher education instructors from regions including North America, Europe, and India, the study finds that while features such as real-time interaction, screen sharing, and chat are present, they fall short in supporting comprehensive learning analytics. To bridge these gaps, the authors advocate for integrating platforms like Acadly, which offer automated attendance, in-session polls, quizzes, and LMS integration—tools that enhance engagement and provide actionable insights for educators.

Purushottama Rao and Janet (2022) developed a Teacher Assistance System (TAS) integrated with Google Meet utilizing computer vision to address the challenge of detecting student distraction in online classrooms. The study focuses on real-time identification of inattentive behaviors and student engagement during virtual learning by analyzing facial cues, such as head pose and eye movement, to assess attention levels. The system processes video feeds using algorithms to deliver real-time feedback on student attentiveness to instructors.

Bullock, Colvin, and Jackson (2021) examine "Zoom fatigue" among higher education faculty during the COVID-19 pandemic, focusing on technostress induced by extensive use of video conferencing platforms (e.g., Zoom,

WebEx, Adobe Connect) for remote teaching. The study, situated within the abrupt transition to online learning, explores the cognitive and emotional strains associated with sustained virtual engagement. Highlighted features of these technologies include real-time communication, screen sharing, and the demand for continuous self-monitoring. Drawing on the technostress model, the authors recommend strategies such as scheduled breaks, clear work-life boundaries, and maintaining offline social interactions to alleviate fatigue.

3.1.2 General perspectives on educational programs, institutions, and inter-personal interactions

Supervisor–student relationships: Alshahrani et al. (2020) employed a qualitative research design using semi-structured interviews with 15 postgraduate students (9 male, 6 female, aged 22–34) at King Saud University in Saudi Arabia. Participants were selected based on their involvement in research supervision and experience using online video conferencing tools for academic purposes. The research was conducted in the context of higher education's growing reliance on digital platforms, motivated by longstanding communicaion gaps in supervisor–student relationships and the rising need for remote interaction, especially amid the COVID-19 pandemic. The study explored how video conferencing supported supervisory practices by examining participants' experiences with various platform features. Thematic findings revealed key advantages such as flexibility, enhanced communication through screen and file sharing, and session recording for better understanding and retention. Challenges identified included limited scheduling features of video conferencing software and occasional connectivity issues.

Webcam on or off during VCS use: (1) Gherheș, Șimon, and Para (2021) conducted a quantitative study involving 407 undergraduate students from Politehnica University of Timișoara, Romania, to explore students' reasons for keeping webcams on or off during online classes amid the COVID-19 pandemic. Data were collected via an online questionnaire administered between December 2020 and January 2021. The study found that over half of the students were reluctant to keep their webcams on, citing reasons such as anxiety, shyness, desire for privacy, and concerns about their surroundings. While some students chose to activate their webcams out of respect for instructors or to enhance interaction, many engaged in parallel activities like working on other projects or household tasks during classes. Regarding technology use, most students participated in online classes using laptops, followed by mobile phones and desktops; no additional hardware accessories were reported as being adopted. (2) Rajab and Soheib (2021) conducted a cross-sectional survey of 412 medical students across Saudi universities during the COVID-19 pandemic (2020–2021) to examine privacy concerns regarding mandatory webcam use in online clinical training. The study, contextualized within emergency remote learning transitions, analyzed video conferencing systems like Zoom and Microsoft Teams, focusing on their camera-based interaction requirements. Findings revealed that 68% of participants perceived webcam mandates as privacy intrusions, leading to reduced camera engagement during sessions, though 74% acknowledged visual communication enhanced clinical skill feedback. No institutional provisions of additional hardware (e.g., privacy filters or upgraded webcams) or supplemental engagement tools (e.g., anonymized participation platforms) were reported. The research highlights a critical tension between pedagogical needs for visual interaction and student demands for privacy in crisis-driven digital education models.

Videoconferencing and Adaptation: (1) Rio-Chillcce et al. (2021) sent out surveys to 10 teachers and 25 students from the University of Sciences and Humanities of the career of Systems and Computer Engineering. The survey examined students' and teachers' familiarity with platforms and the impact of the different video conferencing tools. The findings indicate that videoconferencing platforms such as Zoom and Google Meet were widely used, facilitating fluid communication, breakout room activities, and maintaining engagement, while students reported medium-high proficiency but recognized the need for ongoing digital skills development. Teachers generally felt psychologically and physically prepared for the new modality, although they experienced increased stress and extended working hours. No mention was made of additional hardware accessories being purchased or adopted, nor were other engagement tools beyond the core videoconferencing features reported. General perspectives highlighted that videoconferencing enabled continuity of educational programs, supported institutional adaptation, and fostered interpersonal interactions despite challenges such as network issues and the need for continual pedagogical adjustment. (2) Saidi et al. (2021) conducted a study involving 485 undergraduates from higher education institutions at Universiti Teknologi MARA in Malaysia, focusing on disciplines in Science and Technology, Social Sciences and Humanities, and Business and Management. The research examined students' rapid adaptation to online learning within a university environment. Findings indicated that students preferred video conferencing platforms such as Zoom and Google Meet for their interactive features, while also utilizing messaging apps (e.g., WhatsApp, Telegram) and learning management tools like Google Classroom for communication and assignment management. Regarding learning methods, 46%

of students favored synchronous learning, 24% preferred asynchronous formats, and 30% reported that a hybrid approach combining both methods worked best. Although most students relied on existing devices, some invested in additional hardware (e.g., webcams, headsets) to optimize their online experience, while others adopted supplementary tools to boost engagement and participation. (3) Smolle et al. (2021) conducted a mixed-methods study at the Medical University of Graz to evaluate the implementation of digital tools—including *Microsoft Teams* and *Zoom* for video conferencing, *MedCampus* (the institutional learning management platform), lecture recordings (*Panopto*), and *microlearning modules* (e.g., *Articulate Rise*)—during the COVID-19 transition to remote medical education. The study analyzed data from 1,372 participants (students and faculty) through usage statistics, surveys, and technical logs. Results indicated that while synchronous teaching relied heavily on *Microsoft Teams* and *Zoom*, students prioritized asynchronous *Panopto* lecture recordings for flexibility, with *Articulate Rise* microlearning enhancing comprehension of dense content. Engagement tools such as *Mentimeter* (for live polls/quizzes) and *MedCampus* discussion forums supplemented instruction but saw intermittent participation. The authors noted institutional standardization of *MedCampus* and *Microsoft Teams* to ensure equitable access, with no reported student procurement of additional hardware; however, faculty utilized tools like *Explain Everything* (screen annotation software) to foster interactivity. The findings underscore the effectiveness of blended synchronous-asynchronous systems supported by structured, institutionally managed platforms.

3.1.3 Studies showcasing didactical design and context

This section presents a summary of papers, which included an educational context case that was directly connected to their research. (1) The study by Abdul Rahim (2022) utilized Cisco Webex as the video conferencing system to facilitate a synchronous, remote virtual escape room in a stereochemistry laboratory setting. Students participated in real time using Cisco Webex breakout rooms, which enabled small group collaboration and interactive engagement throughout the activity. The outcome of the study demonstrated overwhelmingly positive student responses, with high ratings for enjoyment, engagement, and teamwork, as well as improved understanding of stereochemistry concepts. The integration of Cisco Webex, alongside digital whiteboard tools, fostered communication and active learning, with students reporting that the virtual format was both fun and effective for collaborative problem-solving. (2) Akkara and Mallampalli (2021) surveyed 200 first- to fourth-year engineering undergraduate students and 30 faculty members from two engineering institutions in Chennai city and Andhra Pradesh (representing both urban and rural contexts) to evaluate the efficacy of existing infrastructure for providing online collaborative learning via video conferencing systems (Zoom and Google Meet), with the aim of assessing student readiness for online collaborative learning and faculty members' capability in adapting to online teaching and assessment. (3) Azman et al. (2021) involved 300 full-time students in the Bachelor of Social Work programme at USM in Malaysia, gathering their perspectives on how the programme managed emergency remote teaching during COVID-19, particularly in addressing the challenges of replacing in-person field work. For online teaching, educators utilized video conferencing systems such as Zoom, WebEx, and Loom, supplemented by audio recordings and e-learning portals for distributing course materials. The pedagogical approach shifted from conventional teacher-centered methods to a blended design that combined synchronous online lectures, asynchronous materials, and proactive distribution of printed and digital resources, especially for students in rural areas with limited internet access. (4) Bhandari et al. (2021) examined the shift to online medical education at Sawai Man Singh Medical College, Jaipur, during the COVID-19 lockdown. Using Cisco WebEx, the institution delivered two daily tele-teaching sessions per MBBS batch over a two-month period. The study surveyed 680 undergraduate students, employing a descriptive cross-sectional design to assess perceptions of this rapid digital transition. Results showed that 72.5% of students found the online classes beneficial, appreciating the relevance and continuity of instruction. However, limitations such as poor internet connectivity and reduced faculty interaction were noted. Despite these challenges, students expressed overall satisfaction and supported the continuation of online classes post-lockdown. (5) Liu et al. (2020) administered a questionnaire to 129 students from three 2018 cohort online classes in the Digital Media Application Technology and Production program at a Chinese university to assess students' comprehensive learning abilities and attitudes within a flipped classroom teaching context. They found that video conferencing systems like DingTalk and Tencent Classroom facilitated real-time interaction in their online flipped blended teaching model, with students demonstrating improved engagement through structured participation in synchronous lectures and asynchronous discussions. The integration of supplementary tools such as Xuexi Qiangguo (for quizzes and resource sharing) further enhanced collaborative learning outcomes, though challenges persisted in sustaining motivation and equitable access among vocational education students.

(6) Morley et al. (2021) developed a virtual curriculum to address Accreditation Council for Graduate Medical Education (ACGME) Level-1 milestones in orthopaedic surgery, initially converting an in-person orthopedic trauma workshop into a non-credited virtual course for 49 third-year medical students from 10 institutions in New Jersey and Pennsylvania during COVID-19 disruptions. The curriculum expanded to include 123 students across multiple institutions, employing video conferencing systems (WebEx, Zoom, Microsoft Teams) for weekly synchronous lectures and interactive small-group sessions, alongside engagement tools like Poll Everywhere, Nearpod, 3D anatomy software (Complete Anatomy), and virtual whiteboards (Miro) for case discussions and procedural simulations. While most students utilized existing hardware, 22% acquired external webcams or microphones to optimize participation. Post-course evaluations revealed 89% of participants reported enhanced clinical reasoning and procedural knowledge, with 93% achieving competency in core ACGME milestones. The authors concluded that hybrid technologies, combining structured virtual sessions with interactive tools, offer a scalable framework for effective remote surgical education, particularly during curricular emergencies. (7) Troja et al. (2021) present a study involving 70 students enrolled in Computer Science and Cybersecurity courses at St. John's University's Division of Computer Science, Mathematics, and Science, part of the Lesley H. and William L. Collins College of Professional Studies. The researchers employed Cisco WebEx's Hands-On Labs tool, alongside features such as chat functionality, student-broadcasted chat to the professor, control assignment functions, wireless access points, network interface cards, and virtual machines. They also developed and applied rubrics to evaluate students' learning curve adoption, asynchronous scheduling flexibility, system response time, engagement levels, and overall course delivery quality. This approach aimed to address challenges posed by emergency remote teaching during COVID-19 by demonstrating how video conferencing systems could facilitate collaborative hands-on laboratory work in group settings. The study emphasized leveraging existing software functionalities rather than purchasing additional hardware, though it utilized institutional infrastructure like wireless access points and virtual machines to support remote lab activities.

Saputra et al. (2021) conducted research in Indonesia by distributing surveys to 86 students enrolled in the Madrasah Ibtidaiyah Teacher Education program at the Tarbiyah Science College of Al-Hilal Sigli. The results were used to classify students into three groups based on their reactions to the implementation of online education: agree, disagree, and doubtful. Four students were selected from each category, and a total of 12 participants took part in telephone interviews and Zoom meetings. The study revealed that while most students owned smartphones and some had laptops, disparities in device ownership and limited internet access posed significant barriers. Zoom Cloud Meetings and messaging applications were used for instruction; however, video conferencing was perceived as costly due to high internet data consumption, leading to a preference for less data-intensive tools. Despite these challenges, students reported increased flexibility in learning, a greater sense of safety when expressing ideas, and enhanced autonomy in managing coursework through platforms such as learning management systems and messaging apps. Nevertheless, issues such as limited instructional clarity, unreliable internet connectivity in rural areas, and difficulties with self-regulation and content comprehension were identified as major drawbacks.

3.2 Video-Conferencing Mediated Educational Activities

This section focuses on the different types of activities in the higher education contexts, where VCS and other student engagement tools are used.

Group Work: The following reviewed papers addressed the use of group work in online learning contexts (Troja et al., 2021; Rahim & Saad, 2022; Liu et al., 2020). Troja et al. (2021) demonstrated the application of group work in a cybersecurity lab environment using virtual machines facilitated through Webex. Similarly, Rahim and Saad (2022) incorporated group work into a remote laboratory setting for foundational topics in Pharmaceutical Chemistry, utilizing a range of digital learning tools such as quizzes, puzzles, Miro boards, YouTube videos, Quizzizz, and Google Forms, also delivered via Webex. Liu et al. (2020) presented multiple strategies for supporting student group work, highlighting the features of QQ communication software, including Q&A sessions, group announcements, shared calendars, and various communication functions. This platform also enabled students to store data, provide and receive feedback, engage in discussions, and facilitate peer exchange.

Chat/instant messaging: The activity of chat and instant messaging is also supported by video conferencing (VC) technologies, as noted by Saidi et al. (2021), Liu et al. (2020), and Vashisht and Gautam (2020). Liu et al. (2020) described how QQ communication software enables both teacher–student and peer-to-peer interaction through its group functions. Saidi et al. (2021) evaluated the preferences of educators and students for social media and chat applications, identifying WhatsApp, Telegram, Email, Facebook, Instagram, and Twitter, in that

order, as the most preferred platforms. Vashisht and Gautam (2020) assessed learning analytics data from learning management systems (LMSs), VC platforms, and instructor-managed chat interactions to classify their roles in supporting instruction. These insights were used to improve the Acadly platform, which is intended for integration with Zoom to enhance its pedagogical effectiveness.

Real-time Q&A, Chat and Announcements: Several studies mention features and methods that enable real-time interaction and questioning during video conferencing sessions, although the specific term "Real-time Q&A" is not consistently used. The Real-time Q&A activity presented by Liu, et al., (2020) is shown in a study that examines the Q&A functionalities of the QQ communication software where students can engage with teachers and each other. The chat feature, hand raising, broadcasting messages found in BigBlueButton, WebEx, and Zoom are found useful in multiple studies (Rio-Chillcce et al., 2021; Vashisht & Gautam, 2020; Pehlivanova. 2023; Khalid at al., 2024; Bullock et al., 2021).

Quizzes and Polls: Quizzes related to videoconferencing (VC) are also a common activity (Vashisht & Gautam, 2020; Azman et al., 2021; Rahim & Saad, 2022). Rahim and Saad (2022) describe the use of multiple-choice quizzes (with single or multiple correct answers), fill-in-the-blank exercises, and polls administered through platforms such as Quizzizz and Google Forms. Azman et al. (2021) offer reflections from both students and teachers, noting that student assessment during emergency remote teaching often involved various media, including quizzes. These were not necessarily conducted via WebEx or Zoom, with alternative platforms like Instagram and WhatsApp also being utilized. Vashisht and Gautam (2020) discuss the integration of quizzes within the Zoom-based VC tool Acadly, which supports automatic grading and other instructional functions.

Discussion functionalities: Discussion functionalities related to VC (Vashisht & Gautam, 2020; Morley et al., 2021; Smolle et al., 2021) are also mentioned in the selected papers. In the paper by Vashisht and Gautam (2020), the Zoom VC layer Acadly enables teachers to ask students to respond to questions in an open-ended manner. Furthermore, Acadly automatically creates archives to retain discussion activities in an organized manner. Morley et al. (2021) describe case-based learning sessions on orthopedic studies, where discussions are central to the learning activity and conducted through WebEx. In Smolle et al. (2021), the WebEx platform was used to engage students in discussions.

Engagement and attendance: Student engagement and attendance (Vashisht & Gautam, 2020; Rahim & Saad, 2022; Puroshottama, 2022) are also reported alongside VC. Rahim and Saad (2022) engaged students with game-based learning activities in an escape room setting, where student responses were monitored by teachers. Vashisht and Gautam (2020) report on attendance, which is recorded through various means such as check-in-based attendance (tracking students who log in to the online class), time-based attendance (tracking student watch time), action-based attendance (where teachers can prompt students with “Are you watching?” and students confirm by tapping a button), and manual attendance registration (where instructors mark students present). Besides attendance, engagement is supported through polls, quizzes, word clouds, discussions, and other resources such as videos, documents, etc., in the Acadly VC platform.

Hands-on teaching: Hands-on teaching activities are presented in some of the papers (Smolle et al., 2021; Troja et al., 2021). Troja et al. (2021) focus on hands-on learning in a laboratory setting using virtual machines via WebEx. Smolle et al. (2021) report the use of the microlearning software *KnowledgeFox* through WebEx to engage students with knowledge cards. Additionally, the LT platform was used as a substitute for internships during COVID-19, leading to the implementation of web-based training.

Case work: The QQ communication software presented by Liu et al. (2020) also encompasses problem-based learning activities and functionalities. However, the specific workings of these functionalities are not exemplified in their study. Case work and case studies are mentioned by Azman et al. (2021) as a means to address the challenges of emergency remote teaching during COVID-19, utilizing technologies such as videoconferencing tools like Zoom and WebEx.

Zoom fatigue: Technostress for educators has emerged under a new label—Zoom fatigue (Bullock et al., 2021). Like technostress, Zoom fatigue negatively impacts both physical and mental health. To address these challenges, Bullock et al. (2021) offered strategies and recommendations grounded in the technostress model as a framework. The suggested strategies and recommendations for educators include the following. (1) Educators to control the physical space: (i) To be more connected and observe the expression educators can keep the laptop or desktop at a comfortable height which can be done also by lifting the screen up with a couple of books to create a straight line., (ii) Avoid cell phone usage during Zoom sessions, and set up a portable and

adjustable webcam into a comfortable position instead of using the laptop/computer camera. (iii) Incorporate built-in breaks for educators and students, along with setup and adhere to a specific start time and end time to avoid feelings of sluggishness. (iv) Take mini breaks, and minimize the window, hide the video call behind an application and try to look away for a few seconds from the computer during the long video calls. (2) Set boundaries: (i) Keep virtual office hours separate from teaching hours. (ii) Dress up professionally while teaching and meeting with students. (iii) Change scenery between meetings. (iv) Enjoy your personal time. (3) Ultimately prevent and/or neutralize Zoom fatigue: (i) Universities can provide training to educators to increase technology literacy. (ii) Create space for faculties to discuss about self care and wellness. (ii) Faculty must know how they can take psychological and social support. (ii) Meditation, podcast, online videos on stress and nutrition module can be offered to the faculties.

3.4 Video conferencing systems and classroom engagement tools

Cavus and Sekyere-Asiedu (2021) conducted a comparative analysis of seven widely used video conferencing platforms, analyzing aspects such as participant capacity, meeting recording duration, security, chat/screen sharing, meeting duration, archive meeting, trial version, account creation to use and mobility.

Table 1. Analysis of seven widely used video conferencing platforms (Cavus and Sekyere-Asiedu, 2021)

Features/platforms	Google meet	Microsoft Teams	Go to Meetings	Cisco Webex Meetings	Zoom Meetings	Click Meetings	Big Blue Button
Maximum Participants	100	300	250	100	100	25	100
meeting recording duration	Limited	Limited	40 min	24 hours	30min	30min	unlimited
security	✓	✓	✓	✓	✓	✓	✓
chat/screen sharing	✓/✓	✓/✓	✓/✓	✓/✓	✓/✓	✓/✓	✓/✓
meeting duration	60min	24 hours	40min	50 min	40min	40min	60min
archive meeting	✓	✓	✓	✓	✓	✓	✓
trial version	Unlimited	6 months	14days tria	7 days trial	unlimited one-on-one meetings	30 days trial	7 days
account creation to us	Not required	Not required	Not required	Not required	Not required	Not required	Not required
mobility	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Amin and Sundari (2020) surveyed 140 Indonesian EFL students from two Jakarta and Aceh universities to evaluate their preferences for Cisco WebEx Meeting, Google Classroom, and WhatsApp during COVID-19-induced remote teaching. Using a questionnaire based on CALL evaluation criteria—language learning potential, meaning focus, learner fit, authenticity, positive impact, and practicality—they found all three platforms were positively received. Cisco WebEx Meeting scored highest in authenticity and meaning focus, Google Classroom in language learning potential, and WhatsApp in practicality and learner alignment. Nonetheless, students generally preferred face-to-face instruction over fully online formats.

Nafrees et al. (2020) sent questionnaires to 400 students at the South Eastern University of Sri Lanka (SEUSL) through WhatsApp, and 310 students responded. Students also mentioned internet connection problems and

challenges with online practical classes. The researchers used qualitative and quantitative methods to determine factors affecting student awareness about online learning. Their study found that mostly female students and humanities stream students preferred video conferencing systems. The study revealed that 51.2% of students used Zoom, but they mostly preferred Webex because of its user-friendliness (ease of use). In response to multiple choice questions regarding reasons for selecting online classes, 47.2% selected "Learning material can be accessed anytime" and 48.8% selected "Flexibility of use of time and location," while "Interaction among students is possible" (12%), "Interaction between instructor and students is possible" (13.3%), and "Tests and assignments can be completed electronically" (21.6%) received lower response rates. However, the paper did not clearly define what the authors meant by user-friendliness.

Akiyama et al. (2021) reported on the implementation of Cisco Webex Education Offer, the trial of Video Mesh function, and Moodle LMS at Kyoto Institute of Technology to enable online meetings and events across their campuses amid COVID-19 restrictions. The report covers Cisco WebEx license types and limits, technological infrastructure integration with the existing environment, user management, and trial use of the video mesh function. Cisco Webex Education Offer allows the use of Active Directory (Cisco Directory Connector) for user management and enables access according to roles. Since the Cisco Webex Desktop app was the primarily used application, the Video Mesh function could be utilized, but the perceived benefits were low.

Azman et al. (2021) highlighted the challenges in using videoconferencing-mediated or online teaching, focusing on content access challenges faced by students and teachers of social work at Universiti Sains Malaysia amid COVID-19 restrictions. The paper lacks clear documentation of the methods applied for data collection, analysis, and reporting. Citing a survey by the Malaysian Ministry of Education (MOE), they reported that out of approximately 0.9 million students, 37% do not have access to any digital technology for learning, and only 6-9% own a personal computer or tablet. The paper states that teaching in social work involves fieldwork and creating appropriate teaching approaches, while the lack of teachers' digital skills and students' access to digital devices and internet connectivity were major challenges. For teaching sessions, WebEx and Zoom (synchronous teaching), Loom (asynchronous video messaging), and audio recordings of lectures were used. For examinations, WebEx and Zoom were utilized. "In order to avoid burnout among students, the social work educators were encouraged to negotiate among themselves in determining assignment weightage of the different social work courses as a means of minimizing and spreading students' workload." It remains unclear whether the online version of the courses resulted in increased assignments or whether the lack of workload distribution balance was inherent and only identified as part of the additional emphasis on learning experience and evaluation.

Video conference platform efficiency comparison:

Chang et al. (2021) investigated the free-tier plans of Zoom, Google Meet, and Webex videoconferencing systems in their evaluation of 48 VC hours over more than 700 sessions, with 200 VM hours rented from 12 geographical locations and 18 hours using two Android phones deployed at two locations. Three of the five findings are related to our review, while the remaining two findings are primarily technology-based. Findings are (1) Streaming lag was experienced. In the US, Webex had 10-70ms, Meet had 40-70ms, and Zoom had 20-50ms streaming lag. (2) Zoom (90-150ms) and Webex (75-90ms) sessions created in Europe experienced higher lag than those in the US, as their infrastructure is based in the US. Due to cross-continental infrastructure differences, sessions held in Europe on Meet experienced smaller lag (30-40ms). (3) These platforms, when processing outdoor videos or dynamic scenes (high motion video), can experience non-negligible Quality of Experience (QoE) degradation compared to low motion video (single person view with a stationary background). (4) "Given the same camera resolution, Webex sessions exhibit the highest traffic rate for multi-user sessions. Meet exhibits the most dynamic rate changes across different sessions, while Webex maintains virtually constant rate across sessions." (5) Meet (1 GB/hour) consumes more bandwidth than Zoom (175MB/hour).

The study by Chang et al. (2021) used an empirical, measurement-based methodology to evaluate the performance of Zoom, Webex, and Google Meet through over 700 controlled video conferencing sessions. Instead of human participants, the researchers deployed emulated clients across 12 global Azure cloud locations and tested real mobile devices to simulate diverse usage scenarios. Conducted during the COVID-19 pandemic, the research addressed the urgent need to assess the reliability and efficiency of widely used video conferencing platforms. The study focused on key performance indicators such as latency, bandwidth consumption, video quality, CPU usage, and battery drain. Thematic findings showed significant differences in infrastructure design, with Google Meet offering more geographically balanced performance and Zoom demonstrating higher

efficiency under constrained conditions. Overall, the analysis highlighted how technical design choices affect user experience and system resource demands, especially in varied network and device environments.

Saidi et al. (2021) disseminated a survey with 13 questions that had two parts: demographic information and undergraduate preferences regarding online class technologies. The survey was distributed through the researchers' network via social media platforms, and a total of 485 students participated voluntarily. However, the purpose of the study was to gather information about preferred technologies used by educators and students. Forty percent of the respondents lived in rural areas and 60% lived in urban areas. The study also reported that 90% of the respondents had previously attended online classes. Findings indicate that students favored synchronous online lessons over asynchronous options, with WhatsApp and Google Meet identified as the primary tools for communication and engagement.

Purushottama & Janet (2022) propose a Teacher Assistance System to detect inattentive students in online platforms by using the OpenCV Caffe model to detect faces and Perspective-n-Point to estimate students' head pose and distance between nose tip and chin point from video data of nineteen Computer Science undergraduate students from two sessions of Google Meet and Webex portals. This model helped to detect distracted pupils with 90.45% accuracy. They claimed that this system/model can be used in online, offline, and hybrid situations. However, Asian and European teaching-learning environments have significant differences. Therefore, the question arises: can we use this model in every culture, and what are we trying to achieve with these findings?

3.5 Challenges and Issues

The challenges grouped under into six categories are: *(1) Technical Issues:* Connectivity issues (poor network connection, bandwidth) are a major concern for students, professionals, and teachers (Mansoor et al., 2024). Device constraints (outdated devices, lack of multiple input devices) affect users (Mansoor et al., 2024). Stability of input devices can be an issue Ling et al. (2024). Lack of features and connectivity problems are noted by teachers (Talmo & Fominykh, 2023). Quality issues with digital solutions (hardware and software) are perceived differently by students and employees, with students facing more difficult conditions on their own equipment (Talmo & Fominykh, 2023). *(2) Pedagogical Challenges:* Professors are not always able to "read the room" online, requiring better pedagogical and technological preparation. "Reading the room" refers to observing facial cues, interactions, and feedback, which can be restricted by technology, perception, or pedagogical preferences (Khalid et al., 2023). Just mirroring physical classroom practices in the digital domain does not work and highlights the need for adjusted pedagogy in VCS (Talmo & Fominykh, 2023). Adapting teaching styles for online environments is necessary and performed by the educators (Khalid et al., 2023). Managing large numbers of students online presents challenges in engagement and interaction (Khalid et al., 2023). Differences exist between physical and online students regarding attentiveness and academic levels (Khalid et al., 2023). Assessment needs innovation and adaptation for online/project-based courses (Bullock et al., 2021). *(3) Interpersonal and Social Issues:* Students report lack of motivation and socialization in VCS-mediated interacting with each other and with the teacher. Navigating the online environment and related rules and behaviour can be a challenge (Khalid et al., 2023). (4) *Resource and Organizational Issues:* Lack of resources such as time, training, and quality LMS is mentioned. Moreover, the system might not be ready for teachers, technicians, or students, requiring better preparation for everyone (Khalid et al., 2023). There can be differences in expectations among the VCS users (Mansoor et al., 2024). (5) *Psychological and Attitudinal Issues:* Focus issues and engagement/attitude problems are reported by students and teachers (Mansoor et al., 2024). Students may find it easy to skip classes online (Khalid et al., 2023).

3.6 Conceptual frameworks, theories and models

Several theoretical frameworks and models are applied or discussed across the sources. (1) *PACT Framework* (Khalid, Tretow-Fish, & Parveen, 2023; Ling et al., 2024; Talmo & Fominykh, 2023) People, Activities, Contexts, and Technologies (PACT) is used to structure interview protocols, analyze data, understand interactions between elements, and classify findings. It helps identify scenarios, practices, issues, and suggestions for enhancement of interactive systems like VCPs. (2) *Learning Paradigms* (Ling et al., 2024): Constructivism and Cognitivism are discussed in relation to features supported by video conferencing. Constructivist features include collaborative learning, problem-solving, interaction, and reflection. Cognitivist features include dialogue and competence. (3) *Signature Pedagogies* (Khalid et al., 2023): It’s defined as concepts of surface, implicit, and deep structure of a profession influencing teaching style. Scenarios in VC-mediated teaching share similarities with certain signature pedagogies like "Traditional classes - Learning by listening" and "Theory framed group work - Learning through

exercises" (4) Group Development Models (Bullock et al., 2021): Tuckman's model (forming, storming, norming, performing) is synthesized into the ICBCI model. The ICBCI model (Introduction, Conflict, Balance, Creation, Identity) aims to deepen the descriptive theory of group stages to be prescriptive for their learning, development, and success, integrating individual and group actions and guiding facilitators. (5) *Experiential Learning* (Bullock et al., 2021): Kolb's model is synthesized into the ICBCI model. (6) *Attachment Theory* (Bullock et al., 2021): Bowlby's model, interpreted by Siegel, is synthesized into the ICBCI model. (7) *Heutagogy* (Bullock et al., 2021): The learning cluster design model is described as reflecting and role-modelling the heutagogy philosophy, allowing the practitioner to choose how to apply the model and be the central strategist. (8) *Hybridity and Multidimensionality* (Bullock et al., 2021): Concepts applied to education to describe combining different forms of learning and teaching. Can involve continuous or discrete spectrums between poles (e.g., group vs individual work). Digitization introduces further dimensions, increasing multidimensionality. Object-oriented analysis and design can be used to model hybrid systems dimensionally. (9) *Dynamic Plan Generation* (Bullock et al., 2021): A graph-based approach that uses finite directed graphs (pin graphs) as building blocks for plans. It has been shown to be probably more expressive than earlier alternatives. Storyboard graphs represent ideas and principles of pedagogy, game design, and their interference. (10) *Communicative Language Competence* (Bullock et al., 2021): Canale and Swain's definition focusing on grammatical, sociolinguistic, and strategic skills, knowledge, and abilities is used for defining foreign language and communication skills. (11) *Organizational Network Analysis* (ONA) (Bullock et al., 2021): A method for studying communication and socio-technical networks within an organization, based on social network theory and dynamic network analysis. It involves visualizing relationships between nodes (people, tasks, groups) and ties (relationships). (12) *Grounded Theory* (Bullock et al., 2021): A methodology used for qualitative data analysis. (13) *Directed Content Analysis (DCA)* (Bullock et al., 2021): A structured process guided by existing theory for content analysis. (14) *Sentiment Analysis* (Bullock et al., 2021): A technique to identify opinions and attitudes. (15) *Triple Bottom Line* (TBL) *model* (Bullock et al., 2021): Promoted as a methodological framework for reporting mistakes and including them as part of a continuous learning process. (16) *Kenneth Burke's Dramatism Theory* (Sofian, 2023): Used to formulate questions in a case study on student behaviour in online learning. (17) *T-shape model* (Bullock et al., 2021): Describes specialization (depth of competences) and generalization (breadth of knowledge for interdisciplinary cooperation). Digitization can add a third dimension to this model. (18) *Complex vs Complicated Problems* (Bullock et al., 2021): Distinguished in the context of thesis work; complicated problems need expert analysis and good practices, while complex problems need rethinking, exploration, sensing, iteration, and evolution.

3.7 Outcomes and Recommendations

Some of the central generalizable findings and recommendations are: (1) *Student and Faculty Perceptions***:** Students evaluate VCS functionalities related to presentation and access/integration highest, and admin features lowest (Pehlivanova, 2023). (2) *Identification of Best Practices*: Synthesizing findings from interviews and focus groups can lead to descriptions of best practices for videoconferencing, sometimes identifying specific tools frequently mentioned (Talmo & Fominykh, 2023). Best practices related to people include using easy-to-access tools and specialized support services (Talmo & Fominykh, 2023). (3) *Challenges Identified*: Specific problems encountered by students, teachers, and IT/e-learning professionals in using VCS are detailed, including technical, pedagogical, interpersonal, and resource issues (Mansoor et al., 2024; Khalid et al. 2023). (4) *Recommendations* (Khalid et al., 2023): (i) Use empirical findings, including identified problems and recommended tools, to inform the design and development of VC toolkits and student engagement tools. (ii) Ideate and test specific video conferencing toolkits and student engagement tools based on identified problems and professor recommendations. (iii) Recognize that strategies for engaging students during VC sessions can also inform and improve face-to-face teaching practices. (iii) Conduct future case studies focused on specific signature pedagogies to explore how VC, engagement tools, and multi-channel interaction are used and evaluated within different professional contexts. (iv) Acknowledge and address diverse digital competencies and willingness (Mansoor et al. 2024). (v) There is a noted lack of effective solutions for physical spaces designed to support these mixed learning environments (Mansoor et al. 2024). (vi) Instead of constantly seeking the newest or "best" equipment, a practical approach involves focusing on the effective use of current tools and existing user skills (Talmo & Fominykh, 2023).

4. Conclusion

This systematic review provides a comprehensive synthesis of empirical studies on video conferencing systems (VCS) in higher education, focusing on pedagogical integration, portability, and student engagement. The most frequently cited platforms include Zoom, Cisco WebEx, Google Meet, Microsoft Teams, BigBlueButton,

GoToMeeting, ClickMeeting, Tencent Classroom, and DingTalk. These systems were employed across a range of instructional formats, including lectures, case studies, labs, and group discussions, indicating their flexibility and adaptability to diverse teaching practices. A key finding is the integration of student engagement tools such as Quizzizz, Google Forms, Poll Everywhere, Mentimeter, Nearpod, Acadly, Xuexi Qiangguo, Miro, and 3D anatomy software (e.g., Complete Anatomy). These tools enriched synchronous sessions through features like real-time Q&A, polls, quizzes, breakout rooms, and collaborative boards, supporting active and participatory learning. Despite these innovations, the review highlights a general lack of hardware adoption beyond basic laptops and webcams. Only a few studies reported the use of external webcams, microphones, or headsets, while institutional tools such as virtual machines, wireless access points, and screen annotation software (e.g., Explain Everything) were occasionally leveraged to enhance teaching. Limited investment in additional resources may have constrained the depth of engagement and the ability to replicate in-person experiences.

Several studies noted the psychological burden of prolonged virtual interaction, now termed Zoom fatigue, and proposed mitigation strategies such as structuring breaks, maintaining ergonomic setups, setting clear boundaries, and offering well-being resources. The role of institutions in supporting faculty through training, peer discussion spaces, and mental health resources was also emphasized.

Importantly, the review reveals a gap in contextual and didactic design across much of the literature. Many studies lacked detailed descriptions of instructional strategies or failed to align VCS functionalities with discipline-specific pedagogies. The application of conceptual frameworks like PACT, signature pedagogies, and experiential learning was limited but showed promise for guiding future pedagogical design.

Given these findings, future research should explore discipline-specific case studies to understand how VCS and engagement tools can be customized to support signature pedagogies. Further investigation is needed into optimizing the physical-digital learning interface, particularly in hybrid settings. Studies should also address the diversity of digital competencies among educators and students to inform inclusive design. Ultimately, the goal should be to develop portable, flexible, and pedagogically robust digital learning environments that go beyond mere technological substitution and actively enhance educational outcomes.

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