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Privacy, security, and usability of mobile video conferencing applications: A comparative study

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ABSTRACT

Mobile learning tools have facilitated authentic learning experiences, allowing students to forge meaningful connections while acquiring real-world knowledge. Mastering the skill of using mobile video conferencing applications is crucial but often complicated for users, such as students, teachers, and employers. In this study, the mobile video conferencing applications Zoom and Webex were compared with respect to their usability, using cognitive load theory as the conceptual framework. A systematic mapping approach was applied to obtain comparative descriptive information from surveyed literature. The available literature on communications support, accessibility and usability, and privacy and security of video conferencing technology was used for the systematic mapping process. The literature review revealed that Zoom and Webex usage can lead to cognitive fatigue, so users must avoid multitasking and schedule breaks between sessions to remain focused. Furthermore, video conferencing tools need to bridge the gap between usability and security for augmented safety of personal information alongside user comfort. Overall, the findings of this study are important for reducing the complexities of mobile video conferencing applications and enhancing the mobile learning experience.

1. Introduction

Mobile applications are designed exclusively for wireless computing gadgets, tablets, and smartphones rather than laptops and desktops (Weichbroth, 2020). Smartphones are the most widely used mobile devices globally, accounting for approximately 82% of these devices. Moreover, the estimated global penetration rate of smartphones was 67% in 2021, with approximately 6 billion users among a population of about 7.4 billion people. However, the implementation of mobile applications in learning can cause unnecessary cognitive load due to improper content design on multimedia tools and excessive information, thereby reducing the effectiveness of the learning process.

Since the release of the first mobile device, most onboard applications have had major usability issues for both hardware and software vendors (Weichbroth, 2020). Although technological advancements have led to more powerful mobile devices and a shift from desktop computing devices, there are several limitations to the former, and usability is the most crucial among them. This is because their success or failure in various market domains depends on how users judge, perceive, and use these applications. Since the introduction of smartphones, the usability of their different applications has been widely studied (Garcia-Lopez et al., 2017), as it is a crucial and interesting factor for software vendors. Researchers have formulated theories concerning various aspects of mobile computing devices, including their construction methods and modeling frameworks, drawing the interest of new manufacturers toward developing functional and high-quality products.

However, despite abundant research on the usability of mobile applications, previous studies on software frameworks, prototyping tools, and design patterns have presented vague results that hinder the evaluability of different constructs. These methodological issues violate the principles and assumptions of the usability concept. In today's fast-paced technological environment, mobile devices have become essential tools for learning due to their omnipresence (Curum and Khedo, 2020). However, the lack of good learning strategies and instructional elements often leads to cognitive overload in users.

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For effective mobile learning using video conferencing technologies such as Webex and Zoom, the learning contents should be restructured and readapted according to proper cognitive models.

Webex and Zoom are mobile video conferencing platforms that are notable for their technological advancements and extensive range of features. They consistently enhance their functionalities to improve the quality of mobile video conferencing. These solutions excel in the realm of mobile video conferencing by enhancing collaboration, facilitating accessibility, and fostering user engagement, especially in education. As learning materials concerning complicated topics are constantly upgraded and redesigned to fit mobile screens, instructional learning models and design principles must be associated with cognitive load theory (Curum and Khedo, 2020). Therefore, this study aims to identify the most imperative features that encourage the use of video-conferencing mobile applications and to evaluate their usability during user interactions. To achieve this goal, different instructional design principles and learning theories crucial for supporting formal and informal learning through mobile instructions were examined, with the cognitive load theory forming the core conceptual model in this study. So, the research objective can be summarized as follows:

- To identify the most critical features that motivate users to improve communication and make scheduling of meetings easier.
- To identify the common and expected usability attributes of mobile video conferencing applications.

Also, the research questions may be outlined as follows:

- How can the usability of mobile video conferencing applications be evaluated based on the cognitive load theory
- How can the gap between usability and privacy/security of mobile video conferencing applications be bridged?

2. Literature review

Remote and open learning systems have become essential for providing quality training and education to people in remote locations at lower costs compared to conventional systems (Gladović et al., 2020). In sparsely populated or remote locations where conventional teaching approaches are less effective, video conferencing has emerged as a plausible, economical, and efficient means of teaching.

Rapid technological development has resulted in the realization of teleconferencing, enabling learners from different locations to engage in face-to-face meetings without being physically present at the same location. Video conferencing is advantageous for businesses and convenient for users as it eliminates travel-related inconvenience, expenses, and time (Gough, 2006). At present, video conferencing is widely used for various purposes such as employment interviews, discussions of commercial agreements, and regular business meetings. The primary advantage of video conferencing over traditional teleconferencing is the visual component, which enables participants to observe one another; this helps develop strong and meaningful relationships. In video conferences, users use web cameras connected to desktops, tablets, laptops, or smartphones, and a software-based platform transmits the communication over various protocols across the internet.

The stability and quality of video conferencing depend on the reliability and speed of the data connection. Since the outbreak of the COVID-19 pandemic, video conferencing adoption has increased worldwide and continues to be crucial in day-to-day life (Karl et al., 2021). With the rapid transformation of professional training, users now have greater flexibility in continuing learning and training sessions (Gladović et al., 2020). Moreover, distance learning is increasingly being adopted because of its economic incentives and advantages, such as facilitating lifelong learning. Today, video conferencing is widely used in various industries, including healthcare, business, and education. It has emerged as an accepted method for instructing students, providing teachers with a new way to present materials and collaborate with learners (Al-Samarraie, 2019). By using two-way compressed video and two-way audio channels along with cameras, teachers and students of an educational institution can communicate effectively (Gladović et al., 2020).

Furthermore, this technology allows learners to learn beyond their textbooks and connects them with the real world (Gladović et al., 2020). Video conferencing, as a form of distance learning, maximizes class benefits by illustrating well the relationship between the use of technology and the need for reorganization (Torrato et al., 2021) and can reach diverse target groups, thus expanding the scope of educational offerings. Some of the popular video conferencing tools are Microsoft Teams, Skype, and Zoom. Other plausible video conferencing tools include Cisco Webex Business, Intermedia AnyMeeting, Google Meet, RingCentral, GoTo Meeting, and Zoho Meeting. This study focuses on Zoom and Webex. Both platforms have made an effort to improve security and privacy features, offer user-friendly mobile interfaces, and be accessible on a variety of devices and operating systems.

2.1. Zoom

Zoom is a cloud-based collaborative video conferencing platform that offers various features, including secure session recording, group messaging, and online meetings. Zoom stands out from other platforms, such as Webex and Skype, because it allows real-time communication between

geographically isolated individuals via mobile devices and computers (Archibald et al., 2019). Zoom often has less streaming lag than other platforms, however, this might change depending on where the users are located (Chang et al., 2022).

Unlike other voice-over-Internet protocol–based technologies, Zoom provides additional benefits that encourage its usage and adoption for video conferencing. For example, Zoom securely retrieves and stores sessions without the need for third-party software, allowing participants to review previous meetings even if they missed the original meeting. This feature is particularly useful for business, healthcare, and educational settings. Additionally, to safeguard sensitive data, Zoom takes several measures such as backing up recordings to various online server networks in remote locations, real-time encryption of meetings, and user authentication. Zoom's storage depends on the cloud, and backed-up recordings can be accessed by authenticated users depending on the shared collaborative purposes of the meetings. Zoom users enjoy the benefits of rapport development with other team members, cost-effectiveness, time efficiency, unlimited access to scheduled meetings, user-friendliness, and simplicity (Archibald et al., 2019). However, some Zoom users have reported issues such as difficulty in joining online sessions and concerns regarding reliability and phone call quality.

2.2. Cisco Webex

Webex is an online application that simplifies user collaboration on projects using audio, video, and images from different locations. This video conferencing tool combines phone communication with computer display. Webex users do not need additional hardware or software; they can access the tool's website to get connected. Moreover, individuals and companies can reduce operational costs and increase productivity using Webex. This tool is ideal for distance learning because users can hold face-to-face meetings.

The key features of this platform include mobility and performance (Dash et al., 2021). The advantages of Webex include cloud recording, powerful whiteboard and application-sharing features, an intuitive interface, and free user plans, while its main disadvantages are limited cloud storage (10 GB) and relatively higher cost.

2.3. Bridging the gap between usability and privacy/security of mobile video conferencing applications

The key difference between Webex and Zoom is that the former offers free plans that allow users to hold meetings for any duration, whereas the latter limits meetings to 40 minutes. Thus, Webex is better for sessions exceeding 40 minutes. Additionally, Webex is commonly used for lengthy meetings and classes/meetings with a high number of participants, while Zoom is used for small group meetings or small-sized classrooms. Nevertheless, both applications have impressive usability, which is likely the main reason for their excellent market reputations.

The two platforms have similar functions, features, and properties; thus, customers can switch from one application to another, considering the market is highly competitive (Zou et al., 2020). The primary areas of competition between the two mobile video conferencing applications include cost implications upon purchase, functionalities, and usability. Currently, Zoom is facing a lawsuit for allegedly sharing or disclosing user data to third parties, including Facebook, without consent. According to the lawsuit, the company's privacy policy fails to inform users about an application code that reveals part of their information to Facebook and other potential third parties. This case highlights the importance of caution when using mobile video technologies and serves as a lesson to users and investors alike. However, achieving proper security and privacy alongside seamless connectivity is difficult. The more connections a platform has with third-party vendors and applications, the higher the likelihood of data being shared and potential shortcomings in its security.

Recently, the integration of Zoom's application programming interface (API) with Facebook led to the sharing of user data; this API was later removed. From this incident, it can be concluded that it is important for a company to invest in tools with clear security and privacy protocols that align with the organization's expectations. However, Zoom does not have an open-source code, and audits are not conducted by third parties (Secara, 2020). Therefore, it is crucial for users to demand transparency and ensure that the company complies with data protection regulations such as the General Data Protection Regulation and the California Consumer Privacy Act. Such regulations ensure privacy rights and consumer protection. The COVID-19 pandemic has had severe consequences on security and privacy protocols as many companies have been forced to foster remote working rather rapidly. However, most businesses still face challenges due to the weaknesses and vulnerabilities of Zoom and Webex that are unknown to them.

Users should conduct due diligence and carefully assess the tools required to support their online business models. Data leakage can severely damage a company's reputation. Therefore, applications such as Zoom and Webex need robust cybersecurity measures. More importantly, user data privacy and security should be straightforward and easy to understand. Mobile video conferencing applications should provide robust, customizable privacy and security measures that comply with their policies. While Zoom and Webex promise customizable protocols for securing user data, it is unclear how they fulfill them.

To ensure a stress-free and fast rollout of these technologies, all necessary privacy and security

requirements must be encompassed upon installation. Users do not want endless options, switches, and toggles, so these platforms should provide an easy-to-use and secure user experience.

Users may face additional privacy risks due to cross-referencing facial image data with social network data (Kagan et al., 2023). While Zoom, Webex, and other mobile video solutions have higher levels of connectivity across remote teams, they apparently do not have strong security.

These platforms are inadequately equipped and not very reliable for essential operations of companies. The codes developed for these platforms often require patching to prevent vulnerabilities and associated costs to users. Thus, there is an urgent need for mobile video conferencing applications that offer security solutions for team collaboration. Currently, secure connectivity is a critical factor for the productivity of remote working applications as teams need to share sensitive Internet Protocols and information. As remote work becomes increasingly prevalent, it is critical for companies to leverage robust technologies that prioritize built-in technologies, productivity, and security.

2.4. Use of cognitive load theory in video conferencing applications

The academic disruptions caused by the COVID-19 pandemic have led educators to adopt just-in-time instructional approaches. However, there is a concern that these approaches do not prioritize the design of instructional content (Omar et al., 2021). Instructions provided by a tutor are stored in the learner's working memory. In online learning, the pace of information delivery determines information consolidation. Rapid introduction of new information makes students' memory clogged. The cognitive load theory, propounded by Sweller (1988) (Sweller et al., 2011), suggests that cognitive load is the amount of information in working memory at any given time (Sweller, 2019). Sweller (2019) observed that working memory has limited capacity. So instructional methodologies should avoid overloading the working memory with activities not necessary for the learning process. Fig. 1 illustrates the information processing model based on the cognitive load theory.

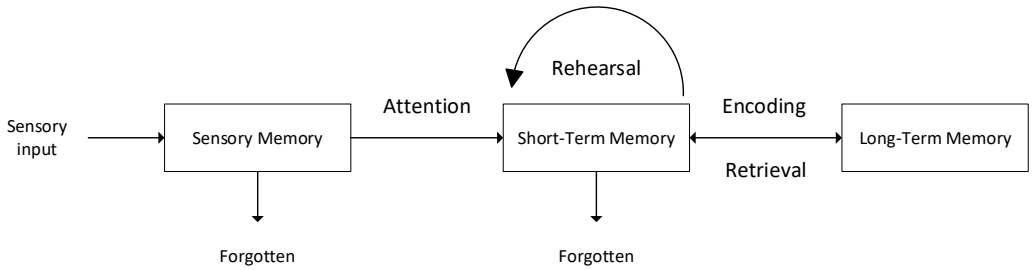

Fig. 1: Information processing model (Atkinson and Shiffrin, 1968)

Based on the cognitive load model, it can be inferred that it is challenging to develop an easily accessible productive mobile video learning system that aids users in learning different concepts using pedagogical reflections and learning styles, surrounding environment, and actual behavior (Curum and Khedo, 2020). Mobile video learning systems are yet to harness the compressive array of robust capacities mobile devices possess for delivering properly adapted elements in mobile learning. Cognitive load management, instructional design principles, and learning effects have not been widely studied for personalized and adaptive learning through pedagogical, physical, and situational contexts. For effective teaching and learning, a learner needs more flexibility and opportunities to adapt to content delivery through instructional design based on current theories, such as multimedia tools.

Incorporation of animations into online learning materials can benefit mobile learning through video applications. Therefore, it is crucial to prioritize mobile learning models that leverage animated trends (Curum and Khedo, 2020). In the future, the utilization of internal context data of students with the features of mobile computing devices will be essential to ensure efficient and accurate real-time information processing.

There are ongoing efforts to personalize learning setups based on a learner's capacity and to inculcate artificial intelligence for monitoring learners' performances and psychology. Such an urge propels education systems to foster distance learning through various strategies. For contextual datasets, encrypted messages, and theories in image fusion, different deep learning techniques and neural networks must be employed. Overall, adjusting learning contents is a collective process involving changes in design principles and cognitive modules to develop better and more efficacious algorithms for learning through mobile video conferencing (Curum and Khedo, 2020). This will reduce ambiguity in learning resources, enhancing learners' instructional definitions, interactions, critical thinking, and understanding.

3. Methodology

A systematic mapping approach was used in this study, aligning with guidelines outlined by Petersen et al. (2008) to yield comparative descriptive information for identifying similarities and

differences in the reviewed literature. The researcher evaluated whether research exists on a given concept and quantified existing evidence. The available literature on communications support, accessibility and usability, and privacy and security of video conferencing applications was reviewed. This approach was preferred because of its capacity to identify the breadth of research areas and provide an overview of the existing evidence. In the context mentioned, the systematic mapping process was employed to investigate concerns regarding mobile video conferencing technologies. Fig. 2 shows the scheme of the systematic mapping approach.

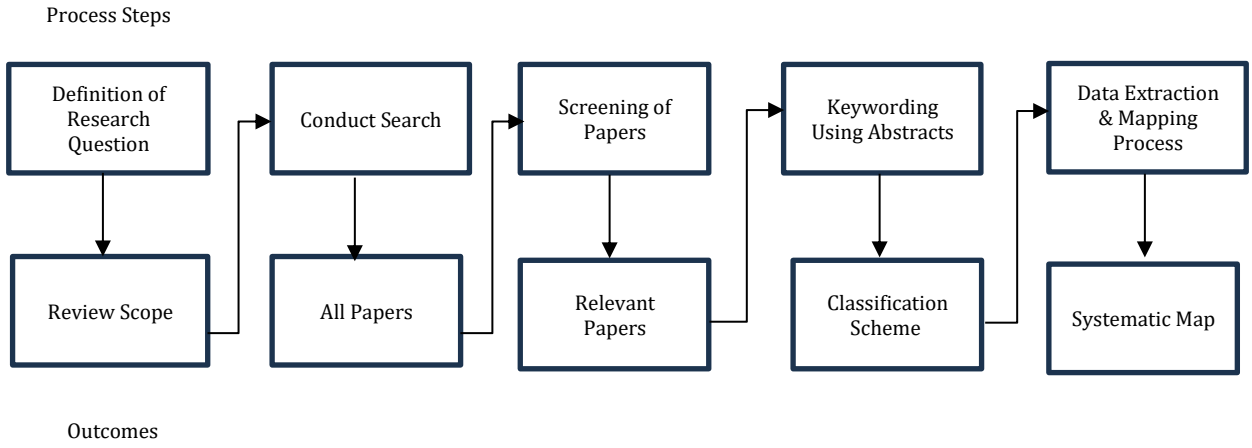

Fig. 2: The systematic mapping process

The five-step systematic mapping process helped identify crucial sections related to the identified concerns regarding mobile video conferencing technologies.

3.1. Defining the research objective

The first step in a systematic mapping process is defining what the research aims to uncover. Here, the research questions were formulated with a primary focus on the specific concerns of mobile video conferencing technologies.

3.2. Collecting relevant materials

Second, relevant scientific materials related to the study's purpose were collected. Following recommendations from Brereton et al. (2007), a search protocol for various scientific databases was created. After pilot searches, the search terms were identified and tested using a plausible combination of various keywords, such as “privacy and security,” “access and usability,” and “communications support,” with the term “mobile video apps,” serving as the key search string. The scientific databases searched for this study included the Saudi Digital Library, the ACM digital library, IEEE Xplore, PLOS One, SpringerLink, and EBSCOhost.

3.3. Literature screening

Third, the available literature was screened. Most of the studies were not associated with the research objectives and were reviewed for the needed content. The exclusion criteria included the nonavailability of full text online, duplicated content, poster papers, and studies older than five years (Kitchenham et al., 2009).

3.4. Keywording

The fourth step involved keywording and comprised two distinct processes: examining abstracts of the identified papers on communications support, usability and accessibility, and security or privacy in mobile video technologies and using the identified keywords for an in-depth understanding of the concepts. This step, inspired by the guidelines of Wohlin (2014), involved discerning the core themes of the selected papers (Fig. 3).

3.5. Data collection and analysis

Finally, information from relevant articles, documents, and books was collected and the following three items were analyzed: paper titles, publication types, and author names (Turner et al., 2010). Furthermore, important findings reported in the papers and objectives of the studies were noted.

A total of 69 papers and articles were included in this study. The abstract review revealed that over 50 of these documents focused on the technical aspects of mobile video applications. Most papers included in this study were published after 2020; this ensured that the content gathered was up-to-date, reliable, and valid. In total, 33 articles and papers specifically focused on usability, accessibility, communications support, and security or privacy related to mobile video technologies. Most papers highlighted possible concerns in using these technologies and ways to address them. In conclusion, systematic mapping provides an organized, structured approach to reviewing a domain. This process ensures that the literature survey is comprehensive, transparent, and reproducible.

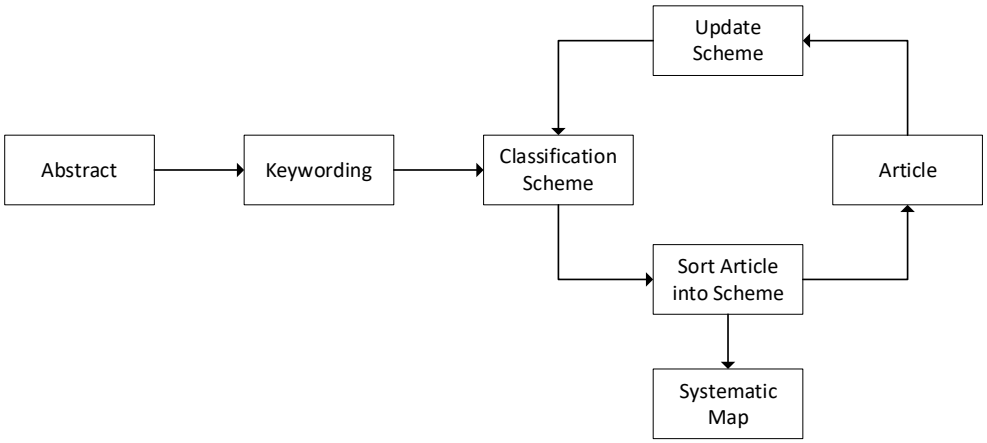

Fig. 3: The keywording phases

4. Results and discussions

4.1. Bridging the gap between usability and privacy/security

With advancements in video conferencing technology, virtual presentations and meetings have become more accessible for companies and educational institutions (Baker and Murphy, 2021). To achieve cost-effective and flexible communication, companies require appropriate tools (Aiken, 2020). Zoom and Webex provide affordable pricing and high-quality videos and audio. Moreover, both platforms offer similar conferencing features, such as screen sharing, file transfers, removal of attendees, and co-browsing. However, Zoom has an advantage over Webex with its integrated breakout sessions, which allow users to avoid experiencing fatigue. Moreover, Zoom has unique participant reporting features that ensure all members are recorded. Both Zoom and Webex emphasize ease of use and user experience. Complicated software interfaces are difficult for users to navigate. Consumer feedback suggests that Zoom is more user-friendly than its rival platforms. The platform allows users to instantly join meetings or conferences and has common features across different devices. The best video conferencing platform for a certain user will depend on their specific needs and requirements (Chang et al., 2022). In video conferencing, security is an important feature (Abukari et al., 2020), and both Webex and Zoom offer highly reliable and secure solutions. Features such as user authentication and communication encryption help optimize these platforms' security. They also provide security in desktop sharing. Both platforms offer encrypted meetups, storage, and transmission and comply with the Health Insurance Portability and Accountability Act.

However, Zoom does not guarantee the privacy of user information. The sharing of Zoom's API with Facebook resulted in the sharing of personally identifiable information such as bank accounts, phone numbers, addresses, and names. Thus, there is a need to bridge the gap between the usability and privacy/security of mobile video applications. Meeting organizers should avoid file sharing with external users, such as Facebook and other third parties, which might put identifiable information at risk. To protect privacy on these platforms, organizers must use waiting rooms to screen participants. Moreover, users must check and ensure they are not accidentally sharing confidential data. Users must also be authenticated and tracked through sign-in prompts without sharing their personal IDs. Lastly, meeting organizers must monitor different metrics related to conferences to establish policies for enhancing user satisfaction and security. Table 1 summarizes the findings regarding the interfaces of the two platforms.

4.2. Usability of video conferencing and cognitive load theory

In line with the cognitive load theory, a study reported that prolonged use of video conferencing platforms can lead to Zoom fatigue (Ramachandran, 2021). Moreover, extreme close-up eye contact during video conferencing can result in Zoom fatigue. Additionally, seeing oneself in real-time during video chats can be mentally exhausting (Fauville et al., 2021). Video chats on Zoom and Webex typically reduce the usual mobility of users, resulting in fatigue. Moreover, according to the cognitive load theory, video chats impose a higher cognitive load on users. Nonverbal communication is a natural part of regular face-to-face interactions; however, this is not always possible in video chats, resulting in increased cognitive effort. Further, gestures may be interpreted differently in video chats. Thus, cognitive load theory–based evaluations suggest that continued use of mobile video conferencing applications causes mental exertion and fatigue (Wiederhold, 2020). To avoid such fatigue, users are encouraged to avoid multitasking and schedule breaks between sessions. They are also encouraged to turn off their self-view and use the 20-20-20 rule for their eyes, which recommends that for every 20 minutes spent staring at the screen, users should look at something else about 20 feet away for 20 seconds. Moreover, meetings on Zoom or Webex should be shortened, and an agenda should be established before the meeting.

Table 1: Comparison of Webex and zoom

	Webex	Zoom
Access and usability	There are four different platform modules for various use cases: Support Center, Training Center, Event Center, and Meeting Center. In addition, the platform supports up to 1,000 attendees and events for up to 3,000 people at an additional cost. It also offers advanced features in administering webinars, including attention and attendance indicators, resulting in unique insights on different user profiles	Only two platform modules can be used in different use cases: Webinars and Meetings. Zoom Meetings has a breakout function similar to Webex Training Center. More importantly, Zoom supports up to 500 users and can be scaled up to 10,000 for webinars at an additional cost. Moreover, Zoom performs better in conditions that exhibit low bandwidth. The platform also allows users to have a virtual background and facilitates screen sharing for different attendees. Furthermore, breakout rooms enable users to split single meetings into other groups
Privacy and security	All meetings require passwords for entry. The platform is overall security-focused due to its previous history as a platform for corporate businesses. The platform also provides end-to-end encryption and has active directory integration for diverse sign-in sessions, as most organizations depend on this feature for their directory services. Often, a one-time password is employed for secured login sessions	The platform has recently been updated to offer different security features comparable to Webex. Still, Zoom does not fully guarantee the privacy of user information. As previously revealed, Zoom shared user information with Facebook APIs, putting personally identifiable information at risk. However, Zoom also offers users a one-time password for secured login during meeting sessions, which can help increase security
Communications	In messaging, native Webex (Webex Teams) can be employed as a feature-rich platform. In addition, the Webex Calling platform also offers telephony rooms and user subscriptions as a mature platform integrated into Webex Teams	Native Zoom Team Chat is available. However, it is not as stable as Webex Teams but can be employed in augmenting Zoom's Slack integration. Moreover, Zoom Phone has been launched as a calling solution. Currently, its features are limited and there is no contact center
Support	The platform provides various support tiers with different service-level agreements, based on a user's level and requirements	Zoom also offers business plans that include add-on support available at a monthly cost, priced for every endpoint connection on the platform

The findings of the study focused on the two leading video conferencing platforms, Zoom and Webex, in terms of access and usability, privacy and security, communications, and support. However, other studies cover various topics, such as the variation of videoconferencing platforms in terms of geographic scope and resource provisioning strategies, which in turn affects the streaming lag that users experience (Chang et al., 2022). Moreover, the study discussed the use of cognitive load theory in videoconferencing applications. According to the Cognitive Load Theory, user cognitive load can have an impact on their performance and learning outcomes, which in turn affects how usable video conferencing systems are. The enhancement of video conferencing usefulness and enjoyment may be achieved through the reduction of cognitive strain.

4.3. Limitations

There are certain limitations to this study. First, the analysis relied on secondary data from previous studies. While the systematic literature review included varied sources of data, ranging from scientific journals to conference proceedings, there is a likelihood that the data sources provided information from small sample sizes that cannot be generalized. Second, this study reviewed only documents published in English. Thus, valid and reputable information published in other languages may have been left out. Third, there is a higher likelihood that the inclusion of the terms "usability," "access," "communications support," "privacy," and "security" left out potentially relevant studies.

5. Conclusions

This study sheds light on critical considerations for enhancing the effectiveness of online learning through video conferencing platforms, with a particular focus on Zoom and Webex. Novice users often face challenges when sharing screens, highlighting the need for intuitive interactions. Ensuring clarity in video conferencing interactions is essential to overcoming this hurdle.

To address the issue of excessive eye contact and fatigue from self-view, employing larger screens and strategically concealing the "self-view" option after proper framing of one's face can significantly alleviate this concern. Moreover, enhancing mobility during video chats by adjusting room settings, such as camera placement, can mimic the pacing of in-person meetings, fostering more engaging discussions. Strategic use of occasional video stream disconnection can offer users nonverbal breaks, minimizing fatigue. A standout recommendation is the implementation of "audio-only" breaks, which allow individuals to temporarily detach from the screen and focus solely on auditory input, ultimately reducing cognitive load.

The study's exploration extended beyond interaction strategies, delving into key aspects of access, usability, privacy, security, and support for Zoom and Webex. Also, the use of cognitive load theory showed how important the link is between user cognitive load, performance, and learning outcomes, which has a big effect on how easy video conferencing systems are to use. Collectively, these insights serve as a comprehensive guide for both users and platform designers, aiming to optimize online learning experiences and leverage video conferencing platforms effectively.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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