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Social VR as an approach to foster collaboration among scientists and educators within the networked infrastructure for education

A pilot case study to examine its and task fit and acceptance

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Zusammenfassung

Mit dem derzeitigen Aufbau einer zentralen Infrastruktur zur digitalen Vernetzung der Bildung will die Bundesrepublik Deutschland die zahlreichen, bestehenden Bildungsplattformen und -angebote technisch miteinander verknüpfen, um einen breiten, nutzerfreundlichen, personalisierten und selbstgesteuerten Zugang zu lebenslangem Lernen zu ermöglichen und die Zusammenarbeit aller Bildungsakteur:innen zu fördern. Dabei besteht eine zentrale Herausforderung darin, hierfür geeignete Technologien zu identifizieren, zu evaluieren, technisch zu vernetzen und didaktisch sinnvoll einzusetzen. Die vorliegende Fallstudie untersuchte Social Virtual Reality (Social VR) als potentiell geeignete Technologie für die wissenschaftliche Zusammenarbeit über die digitale Vernetzungsinfrastruktur. Eine virtuelle wissenschaftliche Konferenz wurde durchgeführt, um die wahrgenommene Passung zwischen Aufgabe und Technologie sowie die Technologieakzeptanz von Social VR in diesem Anwendungskontext zu erfassen. Die Teilnehmenden (N = 31) berichteten eine mittlere bis hohe wahrgenommene Eignung, Benutzerfreundlichkeit und Nützlichkeit der eingesetzten Social-VR, die wiederum zu einer hohen Intention für die zukünftige Nutzung der Technologie führte. Übereinstimmend mit bisherigen Ansätzen zur Integration von Modellen der Aufgaben-Technologie-Passung und Technologieakzeptanz sagte die Eignung der verwendeten Technologie die wahrgenommene Benutzerfreundlichkeit und Nützlichkeit voraus, die wiederum zu einer höheren Nutzungsintention der Social-VR führten. Diese Ergebnisse deuten darauf hin, dass Social-VR für kollaborative Bildungsprozesse im Rahmen von wissenschaftlichen Veranstaltungen angemessen und geeignet ist und sich deshalb für die Anknüpfung an die „Digitale Vernetzungsinfrastruktur für die Bildung" eignet. Übereinstimmend mit früheren Untersuchungen weisen die Ergebnisse jedoch gleichermaßen darauf hin, dass vorhandene Social-VR-Software sowohl unter technischen als auch unter gestalterischen Aspekten weiterentwickelt werden sollte, um ihre Eignung und Nutzerfreundlichkeit weiter zu erhöhen.

Stichwörter: e-learning; virtuelle Realität; Social-VR; virtuelle wissenschaftliche Konferenz; Digitale Vernetzungsinfrastruktur für die Bildung

Abstract

With the current development of a central (digital) networked infrastructure for education, the Federal Republic of Germany aims to technically connect the multitude of existing educational platforms and offerings in order to enable broad, easy-to-use, personalized, and self-governing access to lifelong education and to facilitate collaboration among all stakeholders. Regarding the latter, a key challenge is to identify suitable technologies, and to evaluate, technically connect, and didactically use them thoroughly. In the present case study, we examined social virtual reality (VR) as a technology for scientific collaboration by carrying out a virtual scientific conference to assess perceived task-technology fit and technology acceptance. Participants (N = 31) reported a medium to high perceived fit, ease of use, and usefulness for social VR, resulting in a high behavioral intention for future use of the technology. In line with previous approaches to integrate task-technology fit and technology acceptance theory, the applied technology's fit predicted perceived ease of use and usefulness to result in a higher intention to use social VR. Overall, social VR appears suitable and sufficient for collaboration at scientific gatherings and is, therefore, to be considered a component of the emerging (digital) infrastructure (called "Digitale Vernetzungsinfrastruktur für die Bildung"). However, in line with previous research, the results point to the need for further development of social VR with regard to both technology and design to further enhance its suitability and convenience.

Keywords: e-learning; virtual reality; social VR, virtual scientific academic conference; digital connectivity infrastructure for education

1. Introduction

In the current era characterized by mega trends such as globalization, mobility and new work, collaboration in education and occupation is increasingly shifting to digital respectively virtual spaces. In particular since 2020, numerous organizations and enterprises migrated their collaborative activities to virtual environments (Aquino et al, 2022) and use technologies like social virtual reality (VR) to jointly work on team tasks in education and beyond. In 2021, it has been predicted that most office meetings would take place in those or other similar 3D spaces within three years (Yung et al., 2022). Social VR tools tackle the limitations of conventional videoconferencing, for instance the limited opportunities for social interaction between participants, by creating a spatial environment with realistic opportunities to interact. Through the use of an avatar, social VR enables participants to realistically represent human interactions, like moving their head, navigating in a room as an entire person, or showing full-body gestures. Against the backdrop of increasing globalization and the growing need to raise ecological awareness in response to advancing climate change, we assume that the scenario of virtual collaboration over distance in education and beyond will not lose significance now that the COVID19 pandemic subsides. In consequence, we suggest to consider this trend within the scope of the German ”Digitale Infrastruktur für die Bildung” (DVIB) as a forthcoming (digital) networked infrastructure for education network with the subgoal of fostering participation in collaborative teaching and learning scenarios (DVIB, 2023). As one of 40 pilot projects for the DVIB, our project “Examining the connection of virtual immersive 3D learning platforms to the DVIB using educational institutions as a sample case (AVILAB2)” is currently investigating not only the technological link and implementation but also application cases for the use of social VR in education. Below, we first briefly introduce the emerging central German networked infrastructure for education by describing its components and goals. We then highlight the added value of connecting social VR environments to the DVIB and outline their target audiences. Finally, we present the results of a pilot case study that examined the task-technology fit of social VR as an environment and tool for scientific academic conferences in relation to its acceptance by the users.

2. Theoretical Framework

2.1 The (digital) networked infrastructure for education in Germany

The DVIB is a technological open-source network that aims to provide information, orientation, and secure access regarding educational programs and offers in Germany and Europe on a digital basis (DVIB, 2023). The network is not meant to create another learning environment, but to smartly connect existing educational platforms and offerings in a way that creates user-centric, functionally powerful, if desired personalized, and self-sovereign access to lifelong and cross-sector educational offerings ranging from school to vocational training and continuing education, while simultaneously enabling and supporting collaborative processes. For this purpose, common standards, formats and interoperable structures are being developed, used and tested. In the current pilot stage, more than 30 sample applications are connected to the infrastructure prototype through the use of five core components (DVIB, 2023). First, a personal (1) digital identity enables users to access content self-organized, to participate in collaborative teaching or learning scenarios, and to share information as well as results by authenticating through a single sign-on. A both central and linked (2) wallet is used to store and share data and documents like learning outcomes and certificates obtained throughout individuals' entire educational biography via multiple educational providers and platforms. The trustworthiness of such (3) digital credentials is ensured by deploying a public key infrastructure with certification authorities and central registration authorities as an established standard. An integrated information portal featuring a dashboard and learning path assistant acts as a (4) ‘storefront’ for users to access connected education providers based on their customized search, competency, and needs profile. The processing of requests and deposits within the DVIB is based on a (5) data space (metadata repository) that is used to store non-personal and non-transactional data as a basis for linking learning information and content to learners' individual educational journeys or teachers' customized queries. For an overview of the infrastructure components and their technological relations see Figure 1.

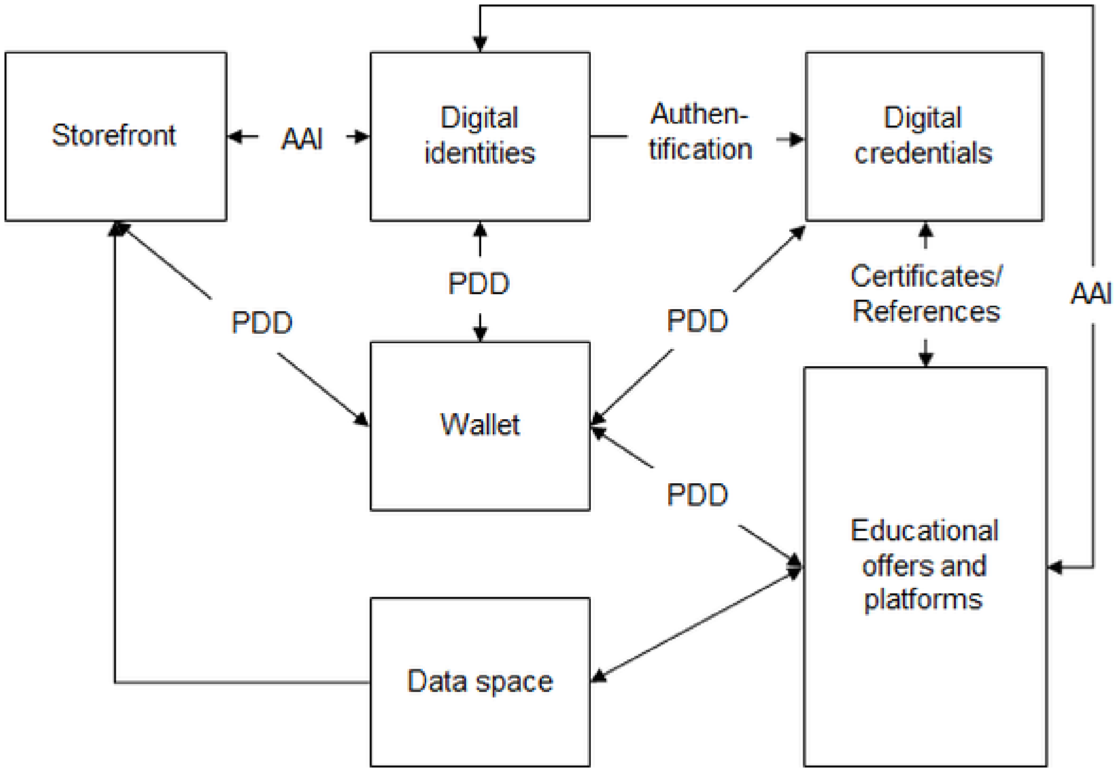

Figure 1: Technological architecture of the DVIB. AAI = authentication and authorization infrastructure; PDD = user's personal data and documents (adapted and translated from DVIB, 2023)

These explanations, taken from DVIB's official website, highlight the platform's focus on not only providing broad, customized, and secure access to educational offerings but also on enabling and supporting collaborative education. In particular, DVIB facilitates productive collaboration and a lively exchange of experiences and between teachers, users and providers of education through the interconnection of different educational institutions. This includes communication and collaboration of the scientific community as the generating entity of knowledge and evidence for the education of individuals. Within this scope, "AVILAB2" uses the technical possibilities of the DVIB to exemplarily connect the social VR software "TriCAT Spaces" and to investigate its suitability for the virtual realization of scientific academic conferences.

2.2 Social VR as a technology to foster collaboration in education

Since the expansion of the world wide web and the increasing equipment of companies and citizens with sufficient bandwidth internet connections, video-based communication has become the means of choice for remote collaboration. Attention in video-based meeting solutions increased in the late 1990s (Finn et al., 1997) when they were also empirically shown to provide a quality of communication that can be considered equal to face-to-face meetings (Olson et al., 1997). Although video calls provide users with multiple advantages, for instance the opportunity to see meeting participants or share their screens with their fellows, they also yield limitations like restricted possibilities for social interaction between participants (Bonfert et al., 2022). Furthermore, in recent years and in particular since the massive increase in the use of videoconferencing software during the COVID19 pandemic, a phenomenon called "Zoom fatigue" occurred more and more frequently. This state, which can be considered a form of computer-mediated communication fatigue, refers to user's exhaustion after participating in many or long video conference meetings (Bonfert et al., 2022). Besides experiencing increased cognitive load or mirror anxiety while permanently seeing one’s self-image, and hyper-gazing from feeling watched by many faces (Bailenson, 2021; Fauville et al., 2023), Zoom fatigue may also result from reduced mobility during video calls (Bailenson, 2021), consequential feelings of being physically trapped (Faulville et al., 2023), and the spatial reduction of conversation partners and their background to a 2D projection (Nadler, 2020). In this regard, social VR may provide a promising alternative for online team meetings, although potential drawbacks like concentration problems, cognitive overload, or VR sickness that may arise over time of use (e. g., Fischer et al., 2021) should not be left aside from this consideration.

Social VR platforms represent “applications that enable geographically remote users to interact with each other in shared virtual environments through VR technology, i.e., immersive head-mounted displays” (Sykownik et al., 2021, p. 537). Today, a multitude of online VR applications with a social component exist, including various characteristics and functionalities (for an overview see Liu & Steed, 2021). Due to its possibility of simulating any communication process in a highly imaginable way, social VR is credited with not only surpassing the experience and effectiveness of communication compared to videoconferencing, but even making it comparable to real-world environments (Moustafa & Steed, 2018; Torro et al., 2021). Recent research indicates that social VR meetings resemble in-person meetings more than video conferences with regard to group dynamics in gatherings before and after the main meeting, or for the impression of being together in the same space (Bonfert et al., 2022). Furthermore, social VR holds huge potential to foster socialization activities, like meeting colleagues in virtuality, as well as playful and creative activities that increase participants' relatedness, enjoyment, and self-expansion (Barreda-Angeles & Hartmann, 2022). Consequently, the use of social VR for online team gatherings may also help to overcome Zoom fatigue.

In the field of education, social VR platforms are recently piloted for various purposes. For instance, they provide a spatio-social environment for lectures, courses, and workgroup meetings but also academic conferences. Their potential as a more environmentally sustainable replacement to both costly and time-consuming conventional formats has been discussed for more than a decade (e.g., Welch et al., 2010). Compared to academic gatherings or lectures held in videoconference, the use of social VR creates a more authentic feeling of a social co-experience with other scientists, lecturers or learners in a common space. In particular, scientific conferences that inherently thrive on the shared event experience, exchange, and networking may greatly benefit from this. Early attempts using the online multimedia platform “Second Life” were considered reasonably successful while mainly suffering from technical issues (Erickson et al., 2011). With advancing technological development, and at least since the outbreak of the COVID19 pandemic, there have been growing attempts to conduct scientific conferences in social VR with increasing success. Accompanying empirical evaluations indicate high overall satisfaction among participants (Ahn et al., 2021) while perceiving lively experiences (Kirchner & Nordin Forsberg, 2021) and performing proxemic interactions between attendees comparable to physical settings also leading to dynamic group formations (Williamson et al., 2021). Given the DVIB's subgoal of encouraging participation in collaborative teaching and learning scenarios, connecting a social VR environment to the digital infrastructure seems both appropriate and purposeful.

2.3 Connecting a social VR environment to the DVIB

In the pilot project "AVILAB2" we exemplarily connect the social VR environment "TriCAT Spaces" to the DVIB. We selected this particular platform because it offers three key advantages: (1) It is hosted by the operating company on servers that are located in Germany and meet DVIB's requirements in terms of data protection and security. (2) It provides a very user-friendly interface and is highly customizable. Predefined room structures for common use cases can be adapted by users based on their individual requirements. In addition, an integrated 3D editor enables the creation of completely new worlds and educational settings. Furthermore, (3) users can access the VR environment in desktop mode while seated, which significantly reduces the risk of suffering from VR sickness.

From a technical view, the social VR software has already been and will continue to be comprehensively connected to the DVIB. Currently, the single sign-on of the DVIB is already available as a prototype, so that users do not need an extra account to access the virtual environment. The interface to the BIRD Wallet app of the DVIB has also already been prototyped, so that information and files (as well as certificates) from educational social VR events can be stored there. To establish a connection, one party must generate a QR code and mark all attributes in optional and mandatory entries that they (1) want to send themselves and (2) require the other party to send. On this basis, we plan to add the ability to generate, store, and transfer certificates that participants have earned at events or learners have acquired in courses (such as credits) in the further development process. Additionally, we intend to automate the booking of virtual rooms within the environment by the use of the DVIB.

The social VR platform is suitable for addressing several key use cases in formal and informal education in Germany. One major use case concerns scientific conferences. Just for the year 2023, conference directories list more than 500 events with a scientific reference to be hosted in Germany (COMS, 2023; IDW, 2023). Since many smaller events in particular are often not registered here, the actual number is estimated to be much higher. With usually at least double-digit and often even three- or four-digit numbers of participants traveling to these events all across the country, the use of social VR enables high resource savings while at the same time providing a realistic event experience - in contrast to mere video conferencing events. Another large target group is formed by the lecturers and students of distance learning universities. In 2021, approximately 190,000 students were enrolled in distance learning programs (IUBH, 2021), with numbers growing steadily. The social VR platform also offers them an authentic and social educational experience. Finally, cross-university teaching where students from two or more public or private on-campus or online universities collaborate with each other remotely (e. g., Breitenstein et al., 2018) is increasingly in demand. This scenario provides a good basis for increasingly cross-regional and globalized business processes in the later professional life of graduates. Consequently, social VR has the potential to increasingly reach these target groups as well.

In preparation for a sustainable connection of social VR environments (like "TriCAT Spaces") with DVIB, it is crucial to first investigate their suitability for the use cases mentioned above and their acceptance by the users. As a first step, we aim to examine these success factors with regard to the case of academic scientific conferences. Beyond the previously mentioned initial empirical glimpses, we however still know very little about the appropriateness of social VR for scientific conferences and its acceptance by participants. Subsequently, we first describe a sound theoretical framework as a basis to examine such factors.

2.4 Task fit and acceptance as key factors for the use of VR for collaboration within the DVIB

As one of the very few recent pilot studies to assess technology appropriateness of social VR for academic conferences, the evaluation of a discussion-driven academic conference on embedding augmented reality and VR technologies in vocational education and training using “AltSpaceVR” showed a high to very high perceived suitability among participants (Zender & Mulders, 2022). Going more into detail, a further study evaluating a virtual scientific conference held via “MozillaHubs” investigated the appropriateness of social VR with regard to typical conference tasks and in comparison to different forms of multimedia platforms (Ahn et al., 2021). Participants reported a low to medium appropriateness for asking questions and learning new skills while perceiving a medium to high suitability of social VR for the activities of listening to talks, discussing research, socializing, and networking, thereby outperforming any further provided kind of tools (such as social network systems and text-based chat platforms). Unfortunately, the exciting results of both studies are limited by the circumstance that they each only measured the suitability of social VR for scientific conferences on the basis of one ad hoc item, which, moreover, is not theoretically substantiated in depth within the articles. The present study tackles this issue by using an integrated approach of the task-technology fit theory and the technology acceptance model as a theoretical foundation as well as the accompanying, validated scales for measurement.

In a nutshell, task-technology-fit theory proposes that tasks and technologies interact to “the degree to which a technology assists an individual in performing his or her portfolio of tasks” (Goodhue & Thompson, 1995, p. 216). Such degree is called task-technology fit and, in turn, predicts users’ reactions and performance moderated by utilization. Although the task-technology theory was never tested entirely, the framework yet received multiple empirical support with regard to its partial links, containing studies in the fields of education and profession (e.g., Kerr & Murthy, 2004; Maity & Dass, 2014). The technology acceptance model describes how users' perceptions of technologies ultimately lead to use (Davis, 1985). With regard to technologies, it proposes that perceived ease of use influences perceived usefulness while both predict users' attitudes. Subsequently, both perceived usefulness and attitudes towards the technology predict users' behavioral intentions to use it, which, in turn, predicts the actual technological use. Similar to the task-technology theory, the technology acceptance model is well supported not only with regard to education and work life (e.g., King & He, 2006; Šumak et al., 2011).

Both the task-technology fit theory and the technology acceptance model share the common goal of predicting how users perceive a technology and to what extent they (will) use it, by taking specific characteristics into account. In consequence, more recent work attempted to integrate both models by substituting the rather general construct of external factors by the more specific characteristic of task-technology fit to create a hybrid theory (Dishaw & Strong, 1999; Howard & Hair, 2023). Notwithstanding minor peculiarities among previous integration approaches, we aim to use their joint core (see Figure 2) as a sound theoretical basis for the present study.

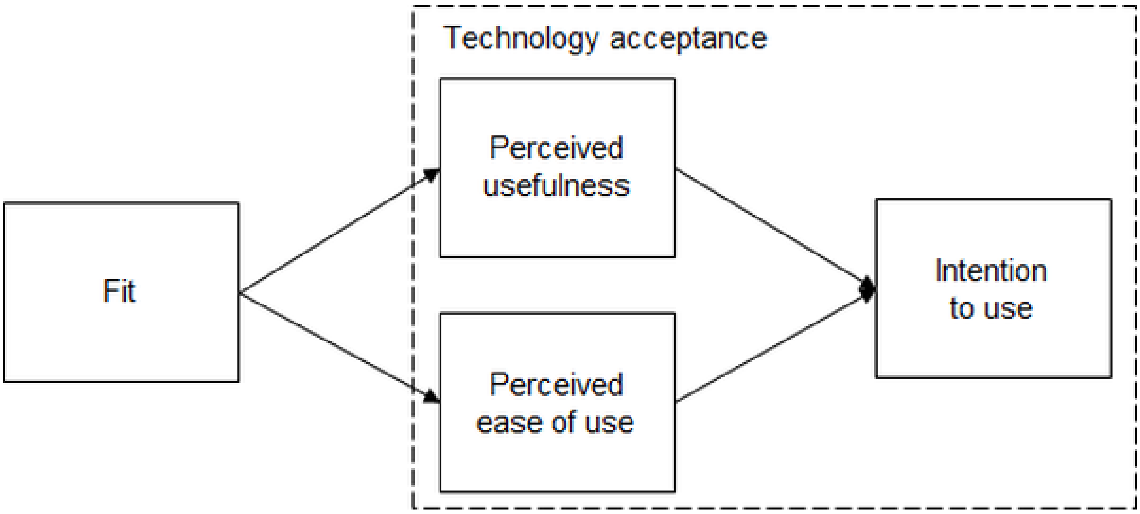

Figure 2: Integrated task fit and acceptance model of technology

On this basis, we investigate whether social VR technologies are to be considered suitable for educational collaboration purposes within the frame of the DVIB with particular focus on scientific academic conferences as a use case. While technology acceptance of general VR in education and profession has at least received some study (e.g., Cabero-Almenara et al., 2023; Li et al, 2022; Pletz & Zinn, 2018), to the best of our knowledge there is neither evidence on the task-technology fit and technology acceptance of social VR nor empirical data on integrated approaches. To address the aforementioned research question and issue, we carried out a methodical rigorous study by the use of valid scales rather than ad-hoc items to measure the to be examined characteristics.

3. Method

3.1 Research environment

Since to date only few scientific academic conferences have been held in social VR, it can be assumed that the majority of scientists do not yet possess experience with this technology and are accordingly not able to submit assessments regarding its acceptance and task fit. Therefore, and in order to provide an authentic field of investigation, a virtual scientific conference was organized and carried out by the "AVILAB2" staff in association with the Center for Open Digital Innovation and Participation and the coordinator of the structured graduate program "Education & Technology" of the Technische Universität Dresden in Germany. The conference was titled "Empirical Status Conference on Digitization in Education and Society" and, consequently, focused the presentation of recent empirical findings regarding the role and use of digital media in education and beyond.

Figure 3: Participants located in the area for virtual exchange and resting

The social VR software "TriCAT Spaces" served to technically create a virtual, immersive 3D conference environment for the conference. The tool provides users with multiple functions to perform activities like (1) customizing their own avatar, (2) exploring the environment in a self-directed manner, (3) interacting with other users (through different possibilities like voice talk, gestures, and text chat), (4) viewing the event plan including the agenda and virtual locations in order to freely choose a session to attend, and (5) importing and managing their own slides and further media (like images, audios, or videos) in the role of a speaker. The conference environment consisted of a virtual plenary hall, as well as an area intended for free exchange among the participants and resting (see Figure 3), and three break-out rooms to host subject-specific parallel sections designed in three different colors. The plenary hall had a large grandstand with seats and a stage with a lectern and giant monitors displaying the presentation and the webcam image of the speakers as well as the conference agenda. The breakout areas each included several tiers of seating for the audience, as well as a stage equipped with a standing desk and large monitor for the presenters, and sections with posters. The networking and resting area contained preview rooms for each section showing its agenda and posters, as well as a hall of fame to honor the highest quality contributions, and a resting room to enable participants to play integrated browser games and videos.

3.2 Procedure

All staff members of the organizing institutions and programs were invited a few weeks prior to the opening of the conference via their usual channels for communication (in particular mailing lists). Participation was mandatory for the scientific staff of CODIP. All additional staff as well as the personnel of the two further hosting organizations were invited to participate voluntarily in the event. Further information and communication regarding the conference also took place through the established channels for communication. Participation in the conference was free of charge. However, in order to facilitate organization, prior registration was requested.

In advance to implementation, a call for papers was issued to gather appropriate submissions. The submitted proposals underwent a peer review process by the organizers based on an evaluation guideline to enable as comparable and transparent feedback as possible. The call was addressed by a total of 12 submissions, which could all be accepted due to sufficient quality and thematic suitability. Accepted speakers were asked to prepare both slides and overview posters to be presented in a digital format. Few days prior to the conference, two trial runs was held simulating the entire process in short in order to familiarize moderators and speakers with the social VR environment and its functions, to clarify technical issues, and to prevent technical problems as well as possible. In addition, a virtual room for individual try-outs and technology checks had been available to all participants one week in advance of the conference.

Figure 4: The virtual conference's keynote speech taking place in the plenary hall

The virtual conference took place on February 6 of 2023 and was opened by a keynote on the role and design of social cues in multimedia learning grounded in the cognitive-affective-social theory of learning in digital environments (CASTLE; Schneider et al., 2022) to take place in the virtual plenary hall (see Figure 4). Subsequent to the keynote lecture, a guided discussion took place, in which the audience had the opportunity to actively participate in the discussion and ask questions to the speaker. Afterwards, the audience split up to attend the talk sessions based on their individual interests. Any of the three sessions consisted of two time slots that each contained two short talks to present results of empirical studies related to the digitization of educational and societal processes. For instance, the presentations addressed competence acquisition and assessment in higher education, and the role of AI and VR support in education. In between, a poster session was held where participants were able to virtually interact with the speakers by asking them questions or telling their opinion and ideas regarding all presented studies. The event closed with a group discussion about the advantages and shortcomings of social VR for scientific gatherings in comparison to other digital tools (like video conferencing systems), carried out in the plenary hall.

Figure 5: A talk being held in the red colored breakout room

Subsequent to the event, a survey was carried out through an online questionnaire provided to all participants of the virtual scientific conference in order to gather data regarding the aforementioned research questions. Participation in the survey was voluntary for the conference attendees. The survey data was exported and evaluated with regard to descriptive statistics and inference in a semi-automated manner using analysis software.

3.3 Measures

A standardized online questionnaire containing a total of 13 bound questions served as the instrument for survey. It measured socio-demographic characteristics of the participants as well as their perceived task-technology fit and technology acceptance. With the exception of participants' technology commitment, ad hoc scales and items were used for sociodemographic data collection. Technology commitment, task-technology fit, and technology acceptance were assessed using well-established and to some extent validated scales (see below). Prior to its use the questionnaire was tested by two experts. The pretest results served as a basis for optimization.

Sociodemographic. Participants' age, *perceived gender*, *qualification*, and *current scientific activities* were assessed by the use of five questions with suitable items (e. g., “Which gender do you feel yourself to belong to?”, offering the options “female”, “male”, “diverse”, and “other”, and "What activity do you currently carry out in the field of science?" providing items like "student assistant", "research associate", and "professor"). *Previous experience* with VR technology and virtual scientific conferences in general, and with regard to social VR in particular, was evaluated by the use of four questions, for instance “How often did you use virtual reality (VR) technologies (like "Occulus Quest", "PlayStation VR" or at the "Time Ride Dresden") prior to the Empirical Status Conference?” and "How often did you participate in online scientific conferences hosted in social VR (e.g., via "AltspaceVR" or "TriCAT spaces") prior to the Empirical Status Conference?". Answers were to be reported on a 5-point Likert scale ranging from "very rare" to "very often". To assess the participants’ technology commitment (α = .80), we used the Technology Commitment Short Scales (Neyer et al., 2012). They encompass four items for each of the three subscales to measure the participants' technology acceptance (α = .73; e.g., "I am very curious about new technical developments."), technology literacy beliefs (α = .78; e.g., "For me, dealing with technical innovations is usually too much of a challenge."), and technology control beliefs (α = .72; e.g., "It mainly depends on me whether or not I am successful in using modern technology.") to be rated on a 5-point Likert scale (ranging from “Does not apply at all.” to “Does fully apply.”).

Task-technology fit. For the assessment of the task-technology-fit, we used the scales by Schrier et al. (2010). They originally consisted of seven items (e.g., "The available options had the appropriate level of detail for my use.") to be assessed on a 5-point Likert scale with the two poles of “Does not apply at all.” and “Does fully apply.”. However, since the performed analysis of the scales' internal consistency showed poor reliability (α = .577), two items ("The software was up-to-date and available when I needed it." and "The functionality of the software was comparable to those of other providers / tools.") were excluded from further analysis. Their exclusion led to an overall reliability that can at least be considered as questionable (α = .615).

Technology acceptance. In order to measure participants' technology acceptance (α = .93), the scales by Davis (1985) were used. They consist of three subscales for perceived ease of use (4 items; α = .89; e.g., “Learning to operate the software was easy for me.”), perceived usefulness (6 items; α = .92; e.g. “Using the software, I can participate more quickly in scientific conferences.”), and intention to use (4 items; α = .90; e.g. “I intend to continue using the software in the future if I have the opportunity to do so.”) that were to be assessed on a 5-point Likert scales ranging from “Does not apply at all.” to “Does fully apply.”.

3.4 Participants

Age, *perceived gender*, *qualification*, and *current scientific activity*. A total of 50 people attended the virtual academic conference, of which 31 (62 %) participated in the voluntary survey. The majority of participants (51,1 %) perceived themselves as female (38.7 %; 3,2 % miscellaneous). They varied in age from 26 and 60 years (M = 37.10 years, SD = 7.81). Of the participants, six persons (19.4 %) were younger than 20, 17 persons (54.8 %) were between 30 and 39, seven persons (22.6 %) were aged 40 to 49, and two persons (6.5 %) were more than 50 years old. Among the subjects, two persons (6.5 %) held a bachelor's degree, while 22 persons (71.0 %) graduated with a diploma, state examination, magister, or master's degree, and seven persons (22.6 %) with a doctorate or habilitation. At the time the conference was held, three participants (9,7 %) were employed as technical staff, 25 participants (80,6 %) were working as research associates, and two participants (6,5 %) held a chair as a professor, whereas one participating person was engaged as a doctoral student without an employment contract in academia.

Prior experience and *technology commitment*. Participants assessed their prior experience with VR technologies rather low (M = 2.0 out of 5; SD = 1.18) in general, and very low to low with particular regard to social VR software (M = 1.52 out of 5; SD = .89), While participants' previous experience with scientific online conferences is to be considered high (M = 4.03 out of 5; SD = 1.20), they only reported a very low to low experience with such conferences held in social VR (M = 1.23 out of 5; SD = .67). Regarding their technology commitment, participants reported high acceptance of technology (M = 3.98 out of 5; SD = .79), high to very high technology literacy beliefs (M = 4.47 out of 5; SD = .59), and medium to high technology control beliefs (M = 3.70 out of 5; SD = .78), resulting in a high overall commitment (M = 4.05 out of 5; SD = .54).

4. Results

Task-technology fit. We performed descriptive statistical analyses to gain insights on the fit of social VR to participant's tasks that consisted of participating and interacting in the virtual conference, or to hold a talk as a conference speaker. According to the results, subjects assessed the task-technology fit of the tool as medium to rather high (M = 3.57; SD = 0.57). The reported averages ranged from 2.60 to 5.00. Out of the 31 participants that answered the survey, 17 (54,8 %) assessed the task-technology fit as medium, whereas eleven subjects (35,5 %) rated the fit as rather high, and three (9,7 %) as very high (see Figure 6).

Technology acceptance. By examining the participant's technology acceptance, subjects assessed their overall level of acceptance as rather high (M = 3.69; SD = 0.77). The reported values ranged in average from 2.00 to 4.86. Out of the 31 subjects that answered the survey, three (9,7%) evaluated the overall technology acceptance as rather low, eight (25,8%) as medium, 14 (45,2%) as rather high, and six (19,4%) as very high (see Figure 6). In terms of the subdimensions, the participants rated their perceived ease of use (M = 3.68; SD = 0.80; 1.75 ≤ Ms = 4.75) and perceived usefulness for the virtual conference (M = 3.52; SD = 1.01; 1.33 ≤ Ms = 5.00) as medium to high, whereas they reported a nearly high intention for future use (M = 3.95; SD = 0.80; 2.00 ≤ Ms = 5.00) of social VR.

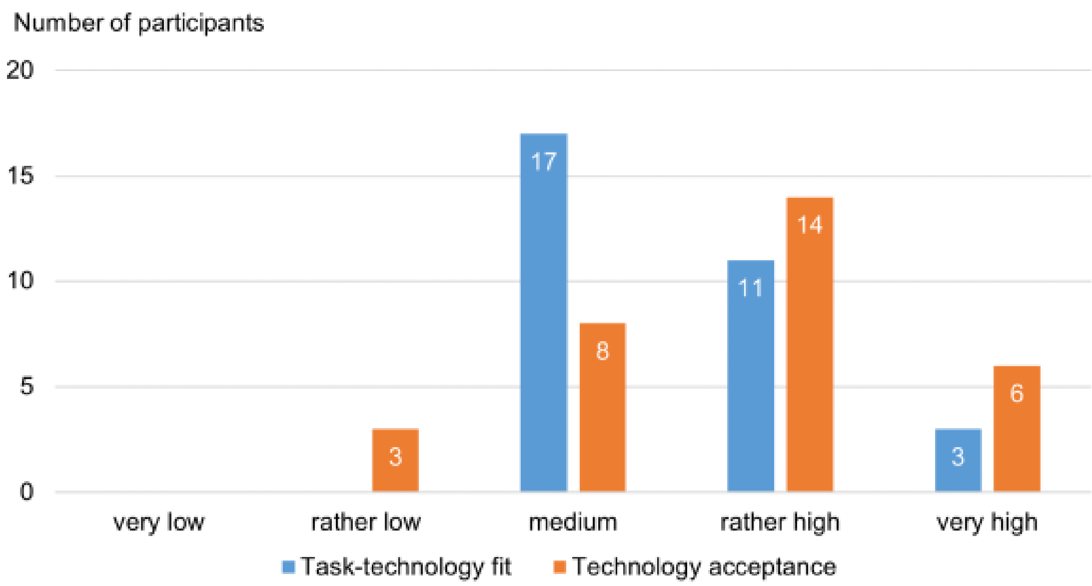

Figure 6: Participants' task-technology fit and technology acceptance of social VR

To examine the extent to which the relationships postulated by hybrid models of task-technology fit and technology acceptance apply for social VR to host scientific academic conferences, regression analyses were performed for task fit and the to be addressed acceptance components for the technology. It shows that the task-technology fit predicts perceived usefulness with a medium effect, $R^2 = .16$, $F(1, 30) = 6.64$, $\beta = .43$, $p = .015$, and perceived ease of use with a large effect, $R^2 = .32$, $F(1, 30) = 15.36$, $\beta = .59$, $p < .001$. According to the subsequently conducted multiple regression, the linear model for perceived usefulness and perceived ease of use as factors to predict the future intention to use social VR reaches statistical significance, thereby explaining almost half of the total variance, $R^2 = .48$, $F(2, 30) = 14.78$, $p < .001$. However, the factor-specific analysis shows that only the technology's perceived usefulness significantly predicted the intention to use, $\beta = .61$, $SE = .13$, $p = .001$, whereas the perceived ease of use did not, $\beta = .17$, $SE = .16$, $p = .307$. These results will be discussed below in reference to similar work and analyzed with respect to their limitations in order to derive implications for DVIB practice and future research.

5. Discussion, implications, limitations and future directions

The present study was conducted to indicate a tendency to whether social VR is to be considered an appropriate and well-accepted tool for scientific academic conferences and should, therefore, be connected to and mapped by the DVIB in order to support the investigated use case among others. Conducted descriptive analyses reveal a medium to high overall task fit and acceptance of the technology reported by the surveyed scientists representing the primary target group. These results indicate a basic suitability of social VR for the examined purpose, but also point to potential for optimization and follow-up research. We see and subsequently discuss causes and links on a technological, design, individual, and research methodological level.

In terms of (1) technology, previous research points out that despite providing advantages in certain aspects, social VR environments still face challenges, for instance high preparation efforts, technical issues, and some discomfort in use like the inability to see other users' real faces and emotions (e.g., Bonfert et al., 2022; Kirchner & Nordin Forsberg, 2021). Furthermore, many currently available off-the-shelf social VR platforms do not yet sufficiently meet the needs and preferences of users for several collaborative purposes, resulting in some teams (at least temporarily) returning to conventional alternatives like videoconferencing systems (e.g., Bonfert et al., 2022). Since many scholars suggest that some of the encountered problems might be resolved within this decade thanks to technical advancements (e.g., Bonfert et al., 2022), we see a promising future to look forward to in this regard. In addition, it should be noted that only one specific social VR platform ("TriCAT Spaces") was applied in the present study. Future studies should compare different platforms in order to obtain more generalizable results.

When it comes to the use of technology for collaboration in education, visual, organizational, and didactical (2) design are important factors to consider. We therefore took a bandwidth of design recommendations into account when organizing and conducting the previously described virtual scientific conference, which were derived from empirical studies. As an example, since previous attempts struggled with spatial audio issues (e.g., Erickson et al., 2011; Kirchner & Nordin Forsberg, 2021), we implemented a sophisticated audio management system, for instance featuring a master voice channel that allowed conference organizers to address the entire virtual environment, as well as (multiple) delineated audio zones within each virtual room. Furthermore, in a previous study virtual conference participants assessed social VR a (rather) high effectiveness for listening to keynotes, talks, and panels, and asking questions to presenters, but not for any conference activities that required interactions with other attendees, like discussing research ideas and building networks (Ahn et al., 2021). Consequently, we followed the advice from previous literature (e.g., Lahlou et al., 2021) to foster any kind of socializing by conducting comprehensive on-boarding, planning poster sessions for professional exchange, and offering functions and possibilities for the formation of small groups to have focused interactions while over time breaking up and remixing into other groups (see Erickson et al., 2011). However, looking at the reported acceptance and suitability scores for our social VR conference, it appears purposeful to adopt additional supportive measures. For example, one may follow and further investigate the promising approach by Ahn et al. (2021) to complement the use of social VR with further digital tools like social network and chat platforms.

Third, users' (3) individual differences may play a role with regard to their perceived task-technology fit and acceptance of social VR for scientific academic conferences. Previous research shows that users differ in various characteristics that impact the way they experience activities and interactions in VR. For example, females and users with higher transportability perceive a greater social presence in virtual environments (Oh et al., 2018), which may in turn make an impact on how they communicate and interact within virtual environments. A further study indicated that higher empathy increases users' engagement with regard to activities in VR (Shin, 2018). It is likely that the users personal experience and behavior in social VR technologies evoked by individual differences will, in turn, influence their subjective perceptions of its task fit and acceptance. Consequently, we suggest to apply the recommendation of studying this aspect more deeply with regard to 360-degree panorama-based interactive virtual learning environments (Dyrna et al., 2022) to the case of social VR as well.

Finally, we recommend to conduct (4) future studies using larger and more heterogeneous samples of users. In the present study, only 31 subjects from academia participated, who on average reported a high level of technology readiness, so that a bias must be assumed to a certain degree. Replicating the study using a larger and more heterogeneous sample, which in particular includes participants with reservations or anxieties towards VR technologies, is likely to generate results of higher validity and thus enables more reliable implications for the integration and mapping of social VR within the DVIB. In addition, similar studies investigating further use cases of social VR in education, like the above-mentioned ones regarding higher education and vocational training, ought to be conducted. For these areas, studies indicate high potentials of the use of Social VR as well (e. g., Le et al., 2015; Mystakidis et al., 2021). A more comprehensive exploration of this kind is, in consequence, likely to make significant contributions to the strategic development of the DVIB. The substantially increased statistical power of broader examinations would also allow them to tackle a furtherly observed issue related to the application of integrated theoretical approaches for task-technology fit and technology acceptance to social VR within the present study. Although the postulated relationships of task-technology fit and perceived usefulness and perceived ease of use as well as perceived ease of use and intention to use were replicated, in contrast to studies on other technologies (Howard & Hair, 2023; Schrier et al., 2021) we did not observe a significant impact of perceived ease of use on intention of future use for social VR. The scope of future studies is to investigate whether this result is replicable with considerably larger samples, thereby performing more holistic assessment like path analysis. Last but not least, future research ought to extend our first quantitative insight with qualitative methodological approaches to dig deeper into why users rate the task-technology fit and technology acceptance of VR at the reported levels and identify which of the just-described features and characteristics affect their ratings in any way. With this in mind, the present study is to be considered a pilot study that ventures into a new segment of social VR research and is intended to engender follow-up research.

References

Ahn, S. J. G.; Levy, L.; Eden, A.; Won, A. S.; MacIntyre, B.; Johnsen, K.: IEEEVR2020: Exploring the first steps toward standalone virtual conferences. In: Frontiers in Virtual Reality, 2, 2021, 648575. https://doi.org/10.3389/frvir.2021.648575 (last check 2023-09-06)

Aquino, J. F.; Riss, R. R.; Multerer, S. M.; Mogilner, L. N.; Turner, T. L.: A step-by-step guide for mentors to facilitate team building and communication in virtual teams. In: Medical Education Online, 27, 2022, 2094529. https://doi.org/10.1080/10872981.2022.2094529 (last check 2023-09-06)

Bailenson, J. N.: Nonverbal overload: A theoretical argument for the causes of Zoom fatigue. In: Technology, Mind, and Behavior, 2, 2021, pp. 1–6. https://doi.org/10.1037/tmb0000030 (last check 2023-09-06)

Barreda-Ángeles, M.; Hartmann, T.: Psychological benefits of using social virtual reality platforms during the covid-19 pandemic: The role of social and spatial presence. In: Computers in Human Behavior, 127, 2022, 107047. https://doi.org/10.1016/j.chb.2021.107047 (last check 2023-09-06)

Breitenstein, M.; Dyrna, J.; Heinz, M.; Fischer, H.; Heitz, R.: Identifying Success Factors for Cross University Computer-Supported Collaborative Learning. In: IAC in Dresden 2018. Teaching, Learning and E-learning (IACTLEl 2018) and Management, Economics and Marketing (IAC-MEM 2018), 2018.

Cabero-Almenara, J.; Llorente-Cejudo, C.; Palacios-Rodríguez, A.; Gallego-Pérez, Ó.: Degree of Acceptance of Virtual Reality by Health Sciences Students. In: International Journal of Environmental Research and Public Health, 20, 2023, 5571. https://doi.org/10.3390/ijerph20085571 (last check 2023-09-06)

Conference Management System (COMS). Konferenzen Deutschland [Conferences in Germany], 2023. Available online: https://conference-service.com/konferenzkalender/de/index.html (last check 2023-09-06)

Davis, F. D.: A technology acceptance model for empirically testing new end-user information systems: Theory and results (Doctoral dissertation). Massachusetts Institute of Technology, Massachusetts, 1985.

Digitale Vernetzungsinfrastruktur für die Bildung (DVIB): Nationale Bildungsplattform [National Education Platform], 2023. Available online: https://bildungsraum.de/display/PROD/Nationale+Bildungsplattform (last check 2023-09-06)

Dishaw, M.; Strong, D.: Extending the technology acceptance model with task technology fit constructs. In: Information & Management, 36, 1999, pp. 90–121. https://doi.org/10.1016/S0378-7206(98)00101-3 (last check 2023-09-06)

Dyrna, J.; Stöhr, K.; Pippig, M.: Do learners experience spatial and social presence in interactive environments based on 360-degree panoramas? A pilot study and future research agenda. In: Köhler, T.; Schoop, E.; Kahnwald, N.; Sonntag, R. (Eds.): Communities in New Media. Digitality and Diversity Overcoming Barriers with digital Transformation. Proceedings of 25th Conference GeNeMe. TUDpress, 2022, pp. 259–268. DOI https://doi.org/10.25368/2023.15 (last check 2023-09-06) URN urn:nbn:de:bsz:14-qucosa2-848672 (last check 2023-09-06)

Erickson, T.; Shami, N. S.; Kellogg, W. A.; Levine, D. W.: Synchronous interaction among hundreds: an evaluation of a conference in an avatar-based virtual environment. In: Tan, D. S.; Fitzpatrick, G.; Gutwin, C.; Begole, B.; Kellogg, W. A. (Eds.): Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, 2011, pp. 503–512. https://doi.org/10.1145/1978942.1979013 (last check 2023-09-06)

Fauville, G.; Luo, M.; Queiroz, A. C. M.; Lee, A.; Bailenson, J. N.; Hancock, J.: Video-conferencing usage dynamics and nonverbal mechanisms exacerbate Zoom Fatigue, particularly for women. In: Computers in Human Behavior Reports, 10, 2023, 100271. https://doi.org/10.1016/j.chbr.2023.100271 (last check 2023-09-06)

Finn, K. E.; Sellen, A. J.; Wilbur, S.: Video-mediated Communication. Lawrence Erlbaum Associates, Mahwah, NJ, 1997.

Fischer, H.; Arnold, M.; Philippe, S.; Dyrna, J.; Jung, S.: VR-based Learning and Teaching. A Framework for Implementation of Virtual Reality in Formal Education. In: Gómez Chova, L.; López Martínez, A.; Candel Torres, I. (Eds.): Proceedings of the 15th International Technology, Education and Development Conference. IATED Academy, Valencia, 2021, pp. 3304–3314. https://doi.org/10.21125/inted.2021 (last check 2023-09-06)

Goodhue, D. L.; Thompson, R. L.: Task-technology fit and individual performance. MIS Quarterly, 19, 1995, pp. 213–236. https://doi.org/10.2307/249689 (last check 2023-09-06)

Howard, M. C.; Hair Jr, J. F.: Integrating the Expanded Task-technology Fit Theory and the Technology Acceptance Model: A Multi-wave Empirical Analysis. In: AIS Transactions on Human-Computer Interaction, 15, 2023, pp. 83–110. https://doi.org/10.17705/1thci.00184 (Error 2023-09-06) https://aisel.aisnet.org/thci/vol15/iss1/4/ (last check 2023-09-06)

Informationsdienst Wissenschaft (IDW): Konferenzen 2023 [Conferences in 2023], 2023. Available online: https://idw-online.de/de/simplesearch?count=7947&_form_=Results&sort_order=start_datetime&words=2023&scope=press_release&scope=event&p (last check 2023-09-06)

IUBH Internationale Hochschule (IUBH): Trendstudie Fernstudium [Distance Learning Trend Study]. IUBH, 2021. Available online: https://res.cloudinary.com/iubh/image/upload/v1614857660/Presse%20und%20Forschung/Studien/202103%20Trendstudie%20Fernstudium/IUBH_Whitepaper_Trendstudie_Fernstudium_16zu10_10_Final_icrtea.pdf (last check 2023-09-06)

Kerr, D. S.; Murthy, U. S.: Divergent and convergent idea generation in teams: A comparison of computer-mediated and face-to-face communication. In: Group Decision and Negotiation, 13, 2004, pp. 381–399. https://doi.org/10.1023/B:GRUP.0000042960.38411.52 (last check 2023-09-06)

King, W. R.; He, J.: A meta-analysis of the technology acceptance model. In: Information & Management, 43, 2006, pp. 740–755. https://doi.org/10.1016/j.im.2006.05.003 (last check 2023-09-06)

Kirchner, K.; Nordin Forsberg, B.: A Conference Goes Virtual: Lessons from Creating a Social Event in the Virtual Reality. In: Krieger, U. R.; Eichler, G.; Erfurth, C.; Fahrnberger, G. (Eds.): Innovations for Community Services. 21st International Conference, I4CS 2021, Bamberg, Germany, May 26–28, 2021, Proceedings. Springer International Publishing, 2021, pp. 123–134. https://doi.org/10.1007/978-3-030-75004-6 (last check 2023-09-06) https://link.springer.com/content/pdf/10.1007/978-3-030-75004-6.pdf?pdf=button (last check 2023-09-06)

Lahlou, S.; Pea, R.; Heitmayer, M.; G. Russell, M.; Schimmelpfennig, R.; Yamin, P.; ... Dawes, A.: Are we 'beyond being there'yet? towards better interweaving epistemic and social aspects of virtual reality conferencing. In: Kitamura, Yoshifuni; Quigley, A.; Isbister, K.; Igarashi, T. (Eds.): Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery. 2021, pp. 1-6. https://doi.org/10.1145/3411763.3451579 (last check 2023-09-06)

Le, Q. T.; Pedro, A.; Park, C. S.: A social virtual reality based construction safety education system for experiential learning. In: Journal of Intelligent & Robotic Systems, 79, 2015, pp. 487-506. https://doi.org/10.1007/s10846-014-0112-z (last check 2023-09-06)

Li, Q.; Liu, Q.; Chen, Y.: Prospective Teachers' Acceptance of virtual reality technology: a mixed study in Rural China. In: Education and Information Technologies, 28, 2022, pp. 3217–3248. https://doi.org/10.1016/j.compedu.2010.10.016 (last check 2023-09-06)

Maity, M.; Dass, M.: Consumer decision-making across modern and traditional channels: E-commerce, m-commerce, in-store. In: Decision Support Systems, 61, 2014, pp. 34–46. https://doi.org/10.1016/j.dss.2014.01.008 (last check 2023-09-06)

Moustafa, F.; Steed, A.: A longitudinal study of small group interaction in social virtual reality. In: Spencer, S. N. (Ed.): Proceedings of the 24th ACM Symposium on Virtual Reality Software and Technology. Association for Computing Machinery, 2018, pp. 1–10. https://doi.org/10.1145/3281505.3281527 (last check 2023-09-06)

Mystakidis, S.; Berki, E.; Valtanen, J. P.: Deep and meaningful e-learning with social virtual reality environments in higher education: A systematic literature review. In: Applied Sciences, 11, 2021, 2412. https://doi.org/10.3390/app11052412 (last check 2023-09-06)

Nadler, R.: Understanding "Zoom fatigue": Theorizing spatial dynamics as third skins in computer-mediated communication. In: Computers and Composition, 58, 2020, 102613. https://doi.org/10.1016/j.compcom.2020.102613 (last check 2023-09-06)

Neyer, F. J.; Felber, J.; Gebhardt, C.: Entwicklung und Validierung einer Kurzskala zur Erfassung von Technikbereitschaft [Development and validation of a brief measure of technology commitment]. Diagnostica, 58, 2012, pp. 87–99. https://doi.org/10.1026/0012-1924/a000067 (last check 2023-09-06)

Oh, C. S.; Bailenson, J. N.; Welch, G. F.: A Systematic Review of Social Presence: Definition, Antecedents, and Implications. In: Frontiers in Robotics and AI, 5, 2018, 114. https://doi.org/10.3389/frobt.2018.00114 (last check 2023-09-06)

Olson, J. S.; Olson, G. M.; Meader, D.: Face-to-face group work compared to remote group work with and without video. In: Finn, K. E.; Sellen, A. J.; Wilbur, S. (Ed.): Video-mediated communication. Lawrence Erlbaum Associates, Mahwah, NJ, 1997, 1997, pp. 157–172.

Pletz, C.; Zinn, B.: Technologieakzeptanz von virtuellen Lern-und Arbeitsumgebungen in technischen Domänen [Technology acceptance of virtual learning and working environments in technical domains]. In: Journal of Technical Education (JOTED), 6, 2018, pp. 86–105. https://doi.org/10.48513/joted.v6i4.143 (last check 2023-09-06)

Schneider, S.; Beege, M.; Nebel, S.; Schnaubert, L.; Rey, G. D.: The cognitive-affective-social theory of learning in digital environments (CASTLE). In: Educational Psychology Review, 34, 2022, pp. 1-38. https://doi.org/10.1007/s10648-021-09626-5 (last check 2023-09-06)

Schrier, T.; Erdem, M.; Brewer, P.: Merging task-technology fit and technology acceptance models to assess guest empowerment technology usage in hotels. In: Journal of Hospitality and Tourism Technology, 1, 2010, pp. 201-217. https://doi.org/10.1108/17579881011078340 (last check 2023-09-06)

Shin, D.: Empathy and embodied experience in virtual environment: To what extent can virtual reality stimulate empathy and embodied experience? In: Computers in human behavior, 78, 2018, pp. 64-73. https://doi.org/10.1016/j.chb.2017.09.012 (last check 2023-09-06)

Šumak, B.; Heričko, M.; Pušnik, M.: A meta-analysis of e-learning technology acceptance: The role of user types and e-learning technology types. In: Computers in Human Behavior, 27, 2011, pp. 2067–2077. https://doi.org/10.1016/j.chb.2011.08.005 (last check 2023-09-06)

Sykownik, P.; Graf, L.; Zils, C.; Masuch, M.: The Most Social Platform Ever? A Survey about Activities & Motives of Social VR Users. In: 2021 IEEE Virtual Reality and 3D User Interfaces (VR). IEEE, 2021, pp. 546–554. https://doi.org/10.1109/VR50410.2021.00079 (last check 2023-09-06)

Torro, O.; Jalo, H.; Pirkkalainen, H.: Six reasons why virtual reality is a game-changing computing and communication platform for organizations. In: Communication of the ACM, 64, 2021, pp. 48–55. https://doi.org/10.1145/3440868 (last check 2023-09-06)

Welch, C. J.; Ray, S.; Melendez, J.; Fare, T.; Leach, M.: Virtual conferences becoming a reality. In: Nature chemistry, 2(3), 2010, pp. 148-152. https://doi.org/10.1038/nchem.556 (last check 2023-09-06)

Williamson, J. R.; O'Hagan, J.; Guerra-Gomez, J. A.; Williamson, J. H.; Cesar, P.; Shamma, D. A.: Digital Proxemics: Designing Social and Collaborative Interaction in Virtual Environments. In: Barbosa, S.; Lampe, C.; Appert, C.; Shamma, D. A.; Drucker, S.; Williamson, J.; Yatani, K. (Eds.): Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, 2022, pp. 1–12. https://doi.org/10.1145/3491102.3517594 (last check 2023-09-06)

Yung, R.; Le, T. H.; Moyle, B.; Arcodia, C.: Towards a typology of virtual events. In: Tourism Management, 92, 2022, 104560. https://doi.org/10.1016/j.tourman.2022.104560 (last check 2023-09-06)

Zender, R.; Mulders, M.: Wissenschaftliche Konferenzen in Social Virtual Reality. Eine Fallstudie [Scientific conferences in social virtual reality. A case study]. In: E-Learning and Education (eleed), 14, 2022. urn:nbn:de:0009-5-55045 (last check 2023-09-06)