



Easily applicable social virtual reality and social presence in online higher education during the covid-19 pandemic: A qualitative study



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ABSTRACT

Social virtual reality (social VR) platforms gained popularity among users over the last few years. They provide users with a sense of social presence, potentially stimulating social interaction in distance education. Insights on how VR enhances the social aspects of learning are scarce, however, and past examinations often focused on the effects of short usage times of self-developed VR learning applications. To analyze the potential of a simple-to-apply off-the-shelf social VR environment in distance education, in this qualitative study, a sample of 35 master's students employed the AltspaceVR platform for university seminars and group work over a six-week while campus access was restricted due to the covid-19 pandemic, and 23 of them were interviewed to examine their perception of the technology. The results show that social VR facilitated feelings of social presence, a more natural and spontaneous way of communicating with peers and teachers, and an increased sense of community in the classroom, compared to the alternative of videoconferencing. Participants reported high acceptance of the technology for teaching and learning tasks, particularly for interactive activities (e.g., workgroups) in small groups, but also identified limitations related to aspects such as image resolution, lack of note-taking tools, or the feeling of dizziness and fatigue after prolonged use. These results highlight the potential advantages of social VR for stimulating the social dimensions of online education, as well as the remaining challenges that need to be addressed to enable its use in higher education.

1. Introduction

The covid-19 pandemic, and the subsequent social distancing measures adopted by most countries, profoundly impacted higher education (Aucejo, French, Ugalde Araya, & Zafar, 2020; Marinoni, Van't Land, & Jensen, 2020). Universities and colleges worldwide were forced to reduce or suspend on-campus activities and switch to online teaching solutions (Crawford et al., 2020). Students had to adapt to these new online teaching and learning formats and cope with drastically reduced social interactions with teachers and peers, which are a fundamental part of the educational process (Lave & Wenger, 1991). Consequently, the covid-19 pandemic posed a challenge to many students, who reported feelings of isolation, boredom, stress, and anxiety (Aristovnik, Keržič, Ravšelj, Tomažević, & Umek, 2020; Son, Hegde, Smith, Wang, & Sasangohar, 2020; Wang et al., 2020).

At the same time, the shift from on-site to online teaching and learning offered an opportunity for innovation and, specifically, for

exploring new information and communication technology (ICT) tools (Peters et al., 2020; Strielkowski, 2020). This move to ICT converged with the advent of virtual reality (VR) technology, which could potentially facilitate social interactions among students and between students and teachers in online teaching. Previous research has shown how VR technology is well-suited to elicit illusions of being physically co-located with others in a virtual space. It enhances feelings of social presence (Kreijns, Xu, & Weidlich, 2022; Oh, Bailenson, & Welch, 2018), which, in turn, is considered a central component of satisfactory online learning experiences (Richardson, Maeda, & Caskurlu, 2017; Sung & Mayer, 2012). Currently, existing social VR platforms (e.g., AltspaceVR, Mozilla Hubs, Engage, Horizon Worlds) offer virtual environments where users can interact with each other embodied in avatars that reproduce their movements in real-time in a way that mimics face-to-face (FTF) interactions (Maloney & Freeman, 2020). Since in-person interactions may help forge social bonds to a greater extent than computer-mediated interactions on a 2D-screen (Sprecher, 2014; Sprecher & Hampton, 2017),

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the simulation of FtF interactions in VR might bring advantages for students' feelings of connectedness compared to other technologies (e.g., videoconferencing; see Hennig-Thurau et al., 2022).

VR has been described as the "learning aid of the 21st century" (Rogers, 2019), and multiple facets of the use of VR in (higher) education have been addressed in previous studies (Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020; Scavarelli, Arya, & Teather, 2021). Most of them have focused on aspects such as user experience or its impact on learning outcomes (cf. Di Natale, Repetto, Riva, & Villani, 2020; Hamilton, McKechnie, Edgerton, & Wilson, 2021; Kavanagh et al., 2017; Radianti et al., 2020). However, scholars have only recently started illuminating the potential of social VR environments to enhance the *social* dimensions of teaching and learning. Social interaction is vital for education, according to diverse educational theories (cf. Scavarelli et al., 2021) and, in particular, social presence is considered central to a successful online learning experience (Garrison, Anderson, & Archer, 1999). Preliminary recent research (e.g., Ripka, Grafe, & Latoschik, 2020, 2021, Foerster, Hein, Grafe, Latoschik, & Wienrich, 2021) started scrutinizing how VR can enhance social connections in the classroom and foster associated psychological outcomes (e.g., social presence, feelings of community), but the amount of existing evidence on the use of *social* VR in higher education is still very limited. Therefore, existing research is unlikely to capture all the nuances of using social VR in higher education. Indeed, researchers in the field (Montagud et al., 2022) have stressed the need for additional empirical studies, particularly on how remote use of social VR (e.g., from home) might affect learning and the classroom feel in higher education.

Another limitation of the few existing studies in this domain is that they have been conducted with small groups of participants and, in most cases, over short periods (e.g., Luo, Li, Feng, Yang, & Zuo, 2021; Ripka, Grafe, & Latoschik, 2020, 2021). A better understanding of this technology requires investigating interaction dynamics in larger groups (Wei, Jin, & Fan, 2022) and with more extended use. Including large groups in research is necessary to effectively compare the use of these technologies with FtF education and videoconference-based courses, which often involve larger groups of students. Examining prolonged use of VR is crucial to understand the dynamic processes that may need time to evolve, such as technology acceptance (Venkatesh, Morris, Davis, & Davis, 2003) or a sense of community in the classroom (Dawson, 2006). Moreover, many previous studies applied social VR-learning environments that were specifically developed for the project or university (e.g., Ripka, Grafe, & Latoschik, 2020), which might not be easily accessible to most teachers. In addition, the economic cost is one of the main barriers to adopt VR in education (Estrada & Prasolova-Førland, 2022), and the use of proprietary solutions is one of the factors that may contribute to this. Free-to-use, off-the-shelf platforms can help alleviating this, by facilitating access to social VR in education. Hence, exploring the application of off-the-shelf social VR tools in education is a relevant, pending task.

The current study takes a step in this direction. We report the results of a qualitative study conducted from October to December 2020, while most on-campus activities (including teaching) at the host university were suspended due to the covid-19 pandemic. The study integrated a VR classroom, implemented in a social VR platform (AltspaceVR), in the teaching activities of a master course in Communication Science. We used the VR classroom for workshops over six weeks, and 35 students (plus two teachers) accessed it simultaneously from home using VR headsets. Students' acceptance of the platform, perceived advantages and disadvantages compared to other options (in-person classes and videoconferencing), and perceived effects on social connectedness and feelings of community were examined using a qualitative, exploratory approach. The results allow us to evaluate the impact of an easily applicable social VR environment on a relatively large group of students and over a more extended period than most of the studies carried out on the subject (Luo et al., 2021), adding new insight into the potential of social VR as a novel

tool in higher education.

2. Theoretical background

2.1. Virtual reality, presence, and learning

In recent years, VR technology has reached maturity and started becoming accessible to the large public (Bailenson, 2018). Modern VR headsets, like the Oculus Quest or HTC Vive Cosmos, are increasingly penetrating the market (IMARC Group, 2021). Some even claim that VR technology may revolutionize how we interact with each other, as other technologies like the internet or smartphones did before (Bastug, Bennis, Medard, & Debbah, 2017; Rosedale, 2017), although it is still an open question whether or not VR will genuinely become a mass medium.

VR technology provides computer-generated 3D environments in which the user can interact in a naturalistic way in real-time (Riva, 2002; Slater & Sanchez-Vives, 2016). Three key processes characterize VR technology (Bailenson, 2018): First, *tracking* captures user's movements in real-time (e.g., users' heads movements via the VR headset or hands movements via handheld controllers). Second, *rendering* ensures that a 3D representation of the content or digital environment is presented that responds to users' actions in real-time (e.g., if users turn their heads, the perspective changes accordingly). Third, *displaying* includes that the presented digital content or environment replaces users' physical environment (e.g., VR headsets block the view on users' physical surroundings and instead offer a virtual 3D surrounding). Different technologies grouped under the VR label (e.g., VR based on computer-generated imagery, 360-video) can provide different levels of interaction. For example, the ability to interact with the environment is limited to varying the visual perspective in 360-video, whereas VR based on computer-generated imagery can provide many more interaction options (e.g., walking within the virtual environment, or manipulating objects; Slater & Sanchez-Vives, 2016).

VR is unique compared to other media technologies because of its immersive technical properties and, thus, the way VR affects its users. Although discrepancies in the terminology exist (Skarbez, Brooks, F, & Whitton, 2017), many scholars use the term *immersion* to describe the system's technical features and the term *presence* to refer to the psychological response experienced while using immersive systems (e.g., Slater & Sanchez-Vives, 2016). Immersion implies that the system blocks users' sensorial perception of the physical world and replaces it with a stream of audiovisual digital content that reacts to users' actions in a way that mimics physical reality (e.g., if users move their hands, their avatars' hands replicate the movement in real-time). Immersive technical features, such as a wide field of view, stereoscopic image, and increased levels of user tracking, contribute to stronger feelings of presence in users (Cummings & Bailenson, 2016). Presence has been defined as the feeling of "being there", physically placed within the virtual environment (Slater & Sanchez-Vives, 2016). It involves a perceptual illusion of *non-mediation* (Lombard & Ditton, 1997) that makes users perceive -and, often, react to- the VR environment as if it were real, even when knowing it is not (Hartmann & Hofer, 2022). Rather than treating presence as a unitarian concept, scholars often differentiate several types of presence, including spatial presence, embodiment or self-presence, and social presence (e.g., Hartmann & Fox, 2021; Lee, 2004; Skarbez et al., 2017). Spatial presence refers to the feeling of being physically located in the virtual environment, embodiment (or self-presence) describes users' sensation that their avatars' virtual body was their actual body, and social presence refers to the perception of being co-located and connected with others (Biocca, Harms, & Burgoon, 2003; Oh et al., 2018).

Numerous authors have pointed out the various advantages of VR environments, and the feelings of presence they induce, in educational contexts (e.g., Jensen & Konradsen, 2018; Nesenbergs, Abolins, Ormanis, & Mednis, 2021; Radianti et al., 2020). The review conducted by Jensen and Konradsen (2018) shows that the use of VR equipment may provide advantages in terms of the acquisition of spatial and visual information,

training of psychomotor and observational skills, and for the development of affective self-regulation skills. A recent meta-analysis by Wu, Yu, and Gu (2020) supports this view, suggesting that VR-based educational interventions increase effectiveness (although with a small effect size) compared to similar non-immersive media interventions.

More specifically, in higher education settings, researchers have primarily focused on the advantages of VR in terms of either enhanced academic performance or increased engagement with the content (Nesenbergs et al., 2021). Regarding performance, VR can provide a realistic interactive simulation of environments and objects not easily accessible -or impossible to access- in reality. This can enhance experiential learning of procedural knowledge (in domains such as engineering, surgery, nursing, biology, or art, among others) and, also, facilitate presenting declarative knowledge in an attractive or easy-to-grasp way (Radianti et al., 2020). However, mixed results have been found regarding the effectiveness of these interventions (Nesenbergs et al., 2021; Radianti et al., 2020), including some results showing a detrimental effect of VR on students' performance in some cases (e.g., Makransky, Terkildsen, & Mayer, 2019; Parong and Mayer, 2018). In contrast to these mixed findings about students' performance, a recent review conducted by Nessember and colleagues (2021) found consistent benefits of using VR regarding students' engagement. Compared to the use of less immersive media, educational experiences in VR increase students' perceived enjoyment, perceived motivation, and positive emotions, and reduce feelings of boredom (e.g., Allcoat & Mühlenen, 2018; Makransky, Andreassen, Baceviciute, & Mayer, 2021; Parong & Mayer, 2018).

Compared to their effects on student performance and engagement, much less research has explored the impact of VR on the social dimensions of education. In the current study, we, therefore, focus on the social impact of using VR in distance education. More specifically, we examine how using a social VR application in teaching affects social presence, communication between students, and feelings of connectedness and community. We explore these questions in a context in which social needs among students were particularly thwarted, due to covid-19 restrictions (Aristovnik et al., 2020), and in which, therefore, a technology that might enhance social presence and feelings of connectedness among students might be particularly valuable.

2.2. Social presence in online learning

Several influential educational theories (e.g., from constructivism to social learning theory) acknowledge the critical role of social processes in learning. Education scholars have shown great interest in how online learning may affect students' social interactions and how the social setting impacts learning experiences (Hill, Song, & West, 2009; Jonassen, Davidson, Collins, Campbell, & Haag, 1995; Tu, 2000). Much of this educational research has revolved around social presence (Whiteside, Dikkers, & Swan, 2017). Researchers have found relevant associations between experiences of social presence and factors like online course retention, final grades, the perceived value of online courses, and students' perceived learning and satisfaction (Edwards, 2021; Kim, Kwon, & Cho, 2011; Liu, Gomez, & Yen, 2009; Richardson, Maeda, Lv, & Caskurlu, 2017; Richardson & Swan, 2019).

It is important to note that social presence is a somewhat ambiguous concept and has been used in various ways in research (Kreijns et al., 2022; Lowenthal, 2010; Lowenthal & Snelson, 2017). Initially defined by Short, Williams, and Christie (1976) as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships", social presence was understood as a medium's ability to transmit social-communicative cues (e.g., non-verbal language). In this view, some media (e.g., phone) allow for a higher degree of social presence while others (e.g., text chat) limit the experience of social presence, making communication more impersonal and hindering social bonding. This perspective was contested in the 1990s, when researchers found that individuals could develop rich social interactions even via media with restricted social bandwidth (e.g., text chats;

Gunawardena, 1995; Walther, 1996). Consequently, some researchers abided by a definition of social presence based on how people subjectively experience online environments. For instance, Garrison (2009) defined social presence as "the ability of participants to identify with the community (e.g., course of study), communicate purposefully in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities" (p. 352). Since then, scholars have used a variety of definitions of the concept, with some focusing more on the qualities of the medium to facilitate social interactions and others pointing more towards social presence as a subjective experience (Lowenthal, 2010; Lowenthal & Snelson, 2017). To clarify the conceptualization of social presence, Weidlich and Bastiaens (2017) propose differentiating between social presence, understood as "the psychological sensation of the other being 'there' and 'present'", and social space, defined as "the network of interpersonal relationships between students" (p. 482). The first part of this distinction aligns with how social presence is often used by scholars examining immersive virtual environments. These scholars stress that social presence is about an illusion of co-location, or co-presence (Skarbez et al., 2017) between users in a virtual space (e.g., "being together with another", Biocca et al., 2003), accompanied by the experience that the thoughts and emotions of the other are accessible (Oh et al., 2018). Accordingly, we also consider social presence as the "moment-by-moment awareness of the copresence of another sentient being accompanied by a sense of engagement with them" (Skarbez et al., 2017).

2.3. Social VR technology

Social VR has been defined as "3D virtual spaces where multiple users can interact with one another through VR head-mounted displays" (Maloney & Freeman, 2020). A plethora of platforms matching this definition have emerged in the last few years (e.g., AltspaceVR, VRChat, Mozilla Hubs, Horizon Worlds). In these platforms, users are represented by avatars that replicate their (at least, head and hands) movements in real-time, and which reproduce users' real voice, allowing them to interact with others' avatars in a way that resembles FtF interaction (e.g., Bailenson & Yee, 2005; Llobera, Spanlang, Ruffini, & Slater, 2010; Rubo & Gamer, 2021). The immersive properties of VR systems (users' tracking, wide field of view, three-dimensional environments, interactivity) foster sensations of spatial presence (Cummings & Bailenson, 2016). If various users are represented and interact in the same VR environment, those factors can, in turn, enhance feelings of social presence (Oh et al., 2018). Hence, these platforms capitalize on the immersive qualities of VR systems to offer users a variety of virtual environments where users feel that *they are there*, in the company of others.

Users currently employ social VR platforms mainly for socializing (e.g., meeting new people, hanging out with friends), entertainment (e.g., playing games), and self-related (e.g., self-expression, role-playing) purposes (Sykownik, Graf, Zils, & Masuch, 2021). The immersive features of these platforms can enhance the perceived meaningfulness of social interactions (Maloney & Freeman, 2020). In this respect, the use of interactive avatars appears pivotal. In social VR users interact with other users via avatars, which are placed in the position where the user's physical body would be and that reproduce their movements in real-time. Users can feel embodied in their avatar, and thus start perceiving their virtual body as their actual body (Kiltner, Groten, & Slater, 2012). Some research suggests that, by interacting with others via embodied avatars, social interactions in social VR are perceived as more natural and closer than interactions based on other media (Maloney & Freeman, 2020; Maloney, Freeman, & Wohn, 2020; Sykownik et al., 2021). Thus, using avatars in social VR, and the sense of embodiment, can contribute to increased feelings of social presence (Heidicker, Langbehn, & Steinicke, 2017; Van Brakel, Barreda-Ángeles, & Hartmann, 2023). In turn, feelings of social presence can enhance users' enjoyment of the interaction and perceptions of relatedness, thus helping to satisfy social affiliation needs

(Barreda-Ángeles & Hartmann, 2022).

2.4. Social VR in educational contexts

Social VR technology appears promising in enhancing the social aspects of distance education by boosting feelings of social presence, particularly when social needs are thwarted (e.g., in lockdowns during the covid-19 pandemic). Some early research has started exploring this potential. In the study conducted by Holt, Heim, Tessens, and Walker (2020), ecology students used the VR platform Mozilla Hubs to present their research projects to their peers in an interactive session, using avatars to interact with others. Students pointed out that the shared (virtual) space facilitated interactions and engagement among peers. However, in this and other studies on the topic (e.g., Gomes de Siqueira, Feijóo-García, Stuart, & Lok, 2021; Guichet et al., 2021), although social VR (e.g., Mozilla Hubs) spaces were used as virtual environments, the participants did not necessarily use VR head-mounted-displays (HMDs) to access them (they were free to use the desktop version). This likely minimized the immersive aspects of the experience and the associated feelings of spatial and social presence.

Little research has been conducted on truly immersive (i.e., HMDs-based) social VR experiences in higher education. One example is the work by Kasapakis and Dzardanova (2021), whose results show that a high-fidelity avatar of the teacher is positively evaluated by students. Yet, in this study, only the teacher used an immersive, headset-based VR, while the students accessed the virtual environment using their PCs. Liaw (2019) carried out a study that explored the effects of using a (low-end) social VR system for intercultural communication learning. Participants reported enjoying the interactions, although, in this study, only a system with limited technical capacities (e.g., lack of interactive avatars) was applied. Yoshimura and Borst (2020) conducted remote lectures with 13 students over seven weeks, both in social VR and using a desktop version of the platform. The students reported an increased sense of presence when using the VR version, but cybersickness emerged as a relevant obstacle to a good quality of experience for many participants.

Recently, some studies started putting the focus on how social VR affects *social outcomes* during teaching and learning activities. In the study by Foerster et al. (2021) preservice teachers reported positive effects of the social platform used on social presence and empathy in the group. Ripka, Grafe, and Latoschik (2020) conducted a study with 15 students of a teacher education course who carried out various tasks in a social VR environment. The results suggest that, even though students found communicating with others in the VR environment challenging, some participants reported experiencing an enhanced community feeling. Other study by the same researchers (Ripka, Grafe, & Latoschik, 2021) found that social interactions felt more authentic in social VR, and that it enhanced feelings of community, compared to videoconference. At the same time, some missing non-verbal cues (e.g., facial expressions) in social VR also made communication harder or less natural for some users.

Despite the apparent value of these initial experiences, the existing research is still sparse, and research with larger samples using social VR for more extended periods can add to the growing body of insight. Indeed, many studies focusing on social outcomes of social VR in education employed very small samples of students (e.g., one to five students using VR simultaneously, in Ripka, Grafe, & Latoschik, 2020, 2021 or just one student in Schröter, Tiede, Grafe, & Latoschik, 2021) only for short periods (e.g., one or two sessions, Ripka, Grafe, & Latoschik, 2020, 2021). Social dynamics might unfold in VR differently between smaller and larger groups (e.g., Zhang, Allon, & Van Mieghem, 2017) and, since social relationships may take repeated interactions to develop, one or two experiences with the technology may not capture the all the potential impact of the system on social connectedness among students. Moreover, to assess whether the technology is acceptable to students, it is also useful to consider a more prolonged use, since technology acceptance (Davis, 1989) increases with level of experience with the technology (e.g., Venkatesh et al., 2003). Therefore, to expand our knowledge of the

potential of social VR technology in higher education, the present study includes using a social VR platform during a complete course with a larger group of (35) students. In particular, we focus on an out-of-the-box, free-to-use platform (AltspaceVR). Some previous investigations (e.g., Foerster et al., 2021; Ripka, Grafe, & Latoschik, 2020, 2021, Seufert et al., 2022) have focused on systems explicitly created for such a project. Despite the interest of this research, these systems may not be accessible to the educational community at large. In addition, their creation from scratch has an economical cost and requires extensive technical expertise, which may not be affordable for many educational institutions. Thus, using existing off-the-shelf solutions can be more cost-effective (Calvo, Rotaru, Freire, & Fernandez-Manjon, 2016) and, therefore, more accessible to diverse academic communities.

To understand how social VR can affect the social dimension of online education, first, it is essential to examine the extent to which the technology is acceptable to students. Technology that is hard to use, or that produces discomfort or rejection for some other reason, is unlikely to be adopted in practice, even if it benefits social interaction. Therefore, our first research question (RQ) is as follows.

RQ1: To what extent do students accept current, off-the-shelf, social VR platforms for teaching-learning activities?

Second, a realistic analysis of the advantages and disadvantages of social VR needs to contextualize it in comparison to existing alternatives, such as FtF education or videoconferencing. Previous research has addressed the differences between FtF and social VR educational interactions. It has focused, for instance, either on activities such as simulating a public speaking training environment (Davis, Linvill, Hodges, Da Costa, & Lee, 2020), which did not require learner-teacher interaction; or on learner performance, without analyzing social outcomes (Nas et al., 2020). Some previous research has also employed desktop-VR technologies, which provide a much less immersive experience than headset-based VR (Liaw et al., 2023). Comparing social FtF and social VR interaction in an educational environment, using VR headsets, and employing off-the-shelf applications, a large group of students, and prolonged use, is thus still a pending task. Regarding the comparison of social VR and videoconferencing, previous research shows that social VR increases feelings of arousal and closeness (Campbell, Holz, Cosgrove, Harlick, & O'Sullivan, 2020), and that videoconferencing requires more effort to maintain engagement among communicators (Abdullah, Kolkmeier, Lo, & Neff, 2021). However, again, these preliminary findings are based on studies with small samples and a low number of interactions. The impact of social VR technology compared to videoconferencing in large groups, and with prolonged use, is a question yet to be analyzed. Therefore, our second RQ is as follows.

RQ2: How do VR platforms compare, in terms of experienced social presence and social interactions, to existing alternatives (FtF and videoconferencing)?

Finally, to understand the impact of social VR in education in a broad sense, it is also necessary to consider the specific context of its use. We conducted our study while FtF activities at the university were suspended due to the covid-19 pandemic, which was likely to elicit feelings of isolation in many students (Aristovnik et al., 2020; Son et al., 2020; Wang et al., 2020). It is, therefore, interesting to explore to what extent social interaction in our classroom in social VR can contribute to students feeling more connected to the educational community. Our third RQ is as follows.

RQ3: How do social VR platforms affect students' feelings of connectedness and community "in the classroom", in the context of social distancing measures?

3. Method

To examine our RQs, a study was carried out in which a freely accessible, off-the-shelf social VR platform (AltspaceVR) was integrated into the teaching and learning activities of a course on the social and psychological effects of new media. The study took place from October to December 2020 at Vrije Universiteit Amsterdam, when, due to the covid-19 pandemic, almost all the teaching and learning activities were happening exclusively online in this university. The course was part of the M.Sc. program in Communication Science, and it was taught by two of the authors. The study obtained approval from the Research Ethics Review Committee at the Faculty of Social Sciences, Vrije Universiteit Amsterdam.

3.1. Selection of the social VR platform

Our selection of the social VR platform relied on a set of minimum requirements. The platform should allow (1) use with a VR headset; (2) users to interact with others through interactive avatars; (3) the creation of content such as presentations and posters; (4) the easy creation of space (the classroom) that remained stable throughout the different sessions; (5) the creation of private events (to restrict access to invited students and teachers only); (6) the simultaneous interaction of a large group (40) of users. It should also be (7) freely available and (8) easy to use, even for teachers with little VR experience. It was also important that the installation and set-up of the platform was a simple and intuitive process, given the relatively large number of students, and the fact that the sessions were conducted remotely, which made it difficult to provide extensive support to individual students. Additional requirements were that the platform should allow note-taking and have elements to facilitate crowd management (e.g., host tools to mute users or amplify the user's voice making a presentation).

Based on these requirements, several options for social VR platforms available at the time of the study were analyzed (including AltspaceVR, RecRoom, VRChat, Bigscreen, Spatial, Engage VR, and Mozilla Hubs), as well as a proprietary social VR event platform owned by a company with whom the researchers collaborated. None of the options analyzed fully satisfied all the specified requirements. We opted for AltspaceVR, since, despite some disadvantages (e.g., inability to take notes), it provided the best balance of the different requirements.

3.2. Course activities and integration of social VR

The course consisted of a combination of lectures and workshops. The course lectures were conducted using a videoconference tool (Zoom), while a combination of this tool and the social VR platform (AltspaceVR) was used for the workshops. The pedagogical goal of the workshops was that students learn to conduct experimental research on the psychological aspects of VR as a communication tool, from a media psychology perspective. To achieve this goal, students carried out a student project: in groups of four or five, they were asked to design and conduct a pilot experimental study about a specific psychological effect of VR. At the same time, the workshops would allow the students to get familiar with social VR and provide the scenario to examine our RQs.

The workshops program consisted of six sessions (half of them with a duration of 2 h 45 min, and the rest with a duration of 1 h and 45 min), which took place once per week over six consecutive weeks. To provide a virtual space for the workshops, we created a virtual classroom (see Fig. 1), using the editor of AltspaceVR, consisting of a large meeting room with a big screen for presentations. A VR headset (Oculus Quest 1) was provided to each student so they could use them from home during the course period. The headsets were shipped to the student's homes one week before the start of the workshops. Those were newly purchased devices, and, in the first workshop session, the teachers guided the students through the set-up process, including creating students' avatars to access the class. This session served as a familiarization session with the



Fig. 1. Top row: Overall view of the class (left) and detail of one of the teachers while conducting a seminar (right). Middle row: Overall view of the class during the poster session (left) and a group of students discussing their poster with the teacher (right). Bottom row: Details of students' avatars while conducting their poster presentations.

headset and the AltspaceVR platform, and it also included a first visit to the virtual classroom. Health and safety measures were discussed. During this session, students had time to practice the different aspects of VR (e.g., how to use the controllers, how to interact with other users, how to move across different spaces and worlds, etc.) and the two teachers were present to help solving issues. After the initial session, students were encouraged to keep exploring and getting familiar with the platform. They were asked to visit at least one world within AltspaceVR and attend some event on it before the next session. In the second session of the workshops, these experiences were discussed, and students' remaining technical issues were addressed. After this point, all students were reasonably familiar with the platform and able to use it.

The remaining teaching and learning activities conducted during the workshops included seminars on social-scientific research in VR and methodological aspects, group discussions about the research projects, group tutorials with teachers, and, in the last sessions, the presentation of the results of the students' projects in a virtual poster session conducted in the AltspaceVR classroom. The poster session replicated a real-world poster session, with each group of students standing in front of their poster to explain it to the teachers and other visitors (i.e., other students). Besides the activities conducted in the VR classroom, students also conducted other assignments related to social VR, such as a field trip to different worlds in AltspaceVR and attending some events of their choice

taking place in them, as well as conducting their pilot studies. Fig. 2 summarizes the timeline of these activities.

3.3. Data collection and analysis

After the end of the course, we invited students to participate in on-line semi-structured interviews. Of the 35 students enrolled in the course, 23 students (15 females and eight males, aged between 22 and 28; $M = 23.63$; $SD = 1.25$), agreed to participate in the interviews. All had extensive experience attending courses via videoconference (due to previous courses they had taken when FtF teaching had been suspended due to the covid-19 pandemic), but their experience with VR equipment before this course was minimal (no participant reported being a regular user of VR). Specifically, none of the participants had experience with VR teaching activities. The interviews aimed to collect the participants' perceptions and experiences regarding the three research questions of the study. They included questions such as *How would you describe your experience of using the VR classroom? How did you like the integration of VR during the workshops?* (RQ1) *What did you think about the interactions in VR with your fellow students? How are the interactions on social VR different from interactions on Zoom/the real world?* (RQ2) *Did you feel that VR helped you to socially bond with other students? Why?* (RQ3). The interviewer followed a list of questions as a general guide but could delve deeper into aspects of interest that came up during the interview. Participants were also free to explain other aspects that they found interesting, besides the questions asked. Interviews took about 30 min on average.

All interviews were recorded and transcribed. The strategy for analyzing the data combined elements of thematic analysis (e.g., a focus on identifying recurring themes and patterns in the data; Braun & Clarke, 2006) along with a constant comparison approach based on grounded theory (Corbin & Strauss, 2014). First, a process of *open coding* (Moghaddam, 2006) was used, in which codes were assigned to the interview excerpts, before broad categories were identified that emerged from the codes. A further iteration of the data was then carried out (*axial coding*; Moghaddam, 2006), in which the existing categories and subcategories were reformulated and refined (e.g., by merging similar categories), and the relationships between them were examined. Finally, a *selective coding* process was carried out (Moghaddam, 2006) in which, for each of our research questions, the most central categories, and the relationships between the other categories with them, were identified. Fig. 3 shows an outline of the main categories and subcategories resulting from this process.

4. Results

4.1. Technology acceptance

Regarding our first RQ (*To what extent do students accept current social VR platforms for teaching-learning activities?*), the following categories

emerged during the analysis.

4.1.1. First impressions and “wow” effect

More than half of the students (14 out of 23) reported a very positive first impression about the VR technology (“really cool”; P19, woman; “I really enjoyed it, it's an 8 out of 10”; P12, man; “I liked it a lot because it's new and exciting”, P16 woman) and surprise about how advanced VR technology already is (“I did not expect it to be that real”; P17, woman; “I was really surprised that this was this advanced; I didn't expect such a new thing to be already that responsive and well-developed”, P13, man). These first impressions can be addressed as a *wow-effect* which, however, for some users also faded after a while, due to diverse factors such as cybersickness (see below). With one exception, the rest of the participants (8) also had an overall positive first impression, although they were not particularly enthusiastic about the technology (“I liked it [...] but I don't feel the need to use it” P7, woman).

4.1.2. Technical and practical issues

In general, students reported none or only minor technical issues when using the headset and the virtual classroom from home. A large majority (21) of the participants found the Oculus Quest device intuitive and easy to use (“Everything was self-explanatory”, P4, woman; “I didn't find any obstacle”, P23, woman). The few technical issues described were related to factors such as having a poor internet connection at home, forgetting to charge the headset before class, or not having properly adjusted the headset visual settings in advance, leading to a blurry image. Regarding the use of AltspaceVR and the virtual classroom, overall, participants (19) considered them also intuitive and easy to use, although some (4) pointed out that it required some time to get familiar with the system controllers to allow smoothly moving inside the virtual space and visiting different virtual worlds (“The navigation was not always intuitive”; P10, woman).

Overall, participants did not report many technical or practical difficulties with the use of the system at home. The only remarkable aspect was that some participants (6) reported not having enough space at home to physically *walk* inside the VR environment (i.e., when actual walking in the living room is translated into walking through the VR classroom). Instead, they needed to use other available alternatives to move within the VR classroom (e.g., using the controllers' joystick). However, this solution was not perceived as interfering with the user experience in a relevant manner (“I don't have space to walk with it in my room, but it didn't prevent using it [sitting]”, P16, woman).

4.1.3. Comfort and health issues

Whereas technical issues did not impose major limitations on the use of the system, aspects related to comfort during use did play a more relevant role. Most participants (17) expressed some discomfort-related issues and, among them, the most commonly reported was cybersickness (“a nauseous feeling”, P12, man; “I got a bit dizzy sometimes”, P20,

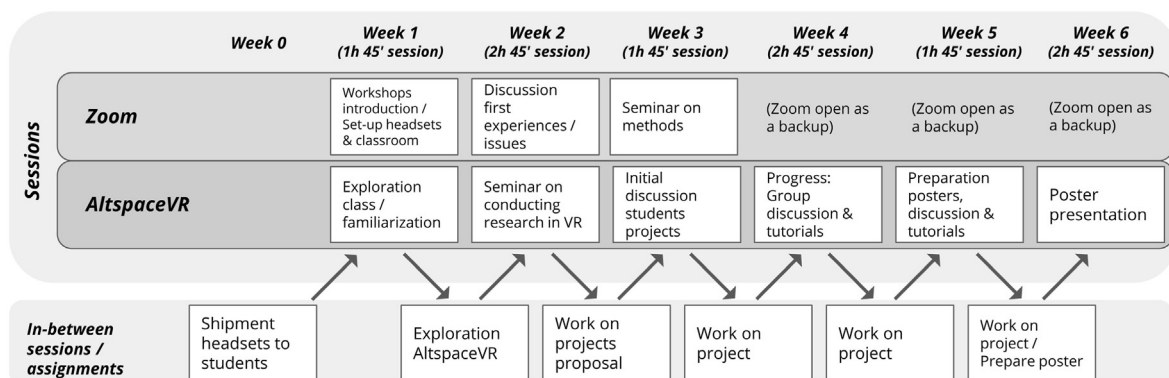


Fig. 2. Timeline and summary of activities conducting during the workshops, and platforms employed.

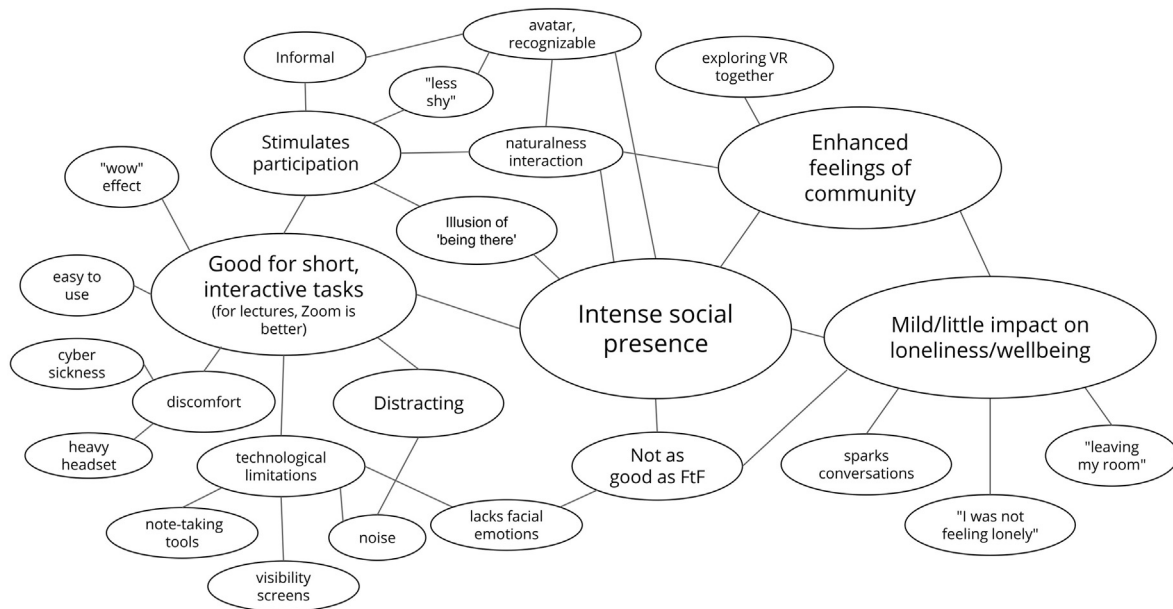


Fig. 3. Bubble chart representing the main categories that emerged during the analysis, and the connections between them.

woman) and headache. About half of the participants (12) experienced some degree of cybersickness, particularly where the use was extended over periods longer than about 30 min, which in some cases was accompanied by a feeling of tiredness ("I often felt quite tired after using the VR", P23, woman). In most cases (9), cybersickness was light and lasted only for a few minutes after removing the headset, but three participants reported stronger feelings of sickness that lasted for more than half an hour. Overall, cybersickness was more common in the first sessions with the system, and it tended to disappear as the course progressed ("I had sickness at the beginning, it went away with use", P18, man). It was also more common when the participants had to move frequently across the virtual space. About half of the participants (10) also reported suffering some degree of headache after prolonged use, due to the weight of the head-mounted display or the pressure of its straps on their heads.

4.1.4. Usefulness and limitations

Most participants (16) considered social VR an attractive, innovative, and exciting tool with great potential for teaching and learning activities ("I really liked the concept", P4, woman; "This is the future", P6, man; "It would be useful in every discipline", P18, man; "VR will be the normal in the future", P19, woman). They stressed, in particular, the social aspect of the experience (see sections 4.2 and 4.3), and that the application allowed for social interactions that felt more vivid and natural than in other online education tools. Some participants (6) noted that those were particularly valuable in a moment where social distancing measures (e.g., online-only education) were enforced ("It was more like a classroom experience, something I miss in these times", P15, woman; "In this situation [the pandemic], VR has way more value than Zoom", P11, woman).

However, students also noted a range of aspects that limited the overall usefulness of the social VR application. These include the inability to take notes within the application; the poor image quality of the screens (e.g., to display slides, posters) within the virtual environment (which made it difficult to read the texts presented, if the participant's avatar was not close to the virtual screen) and distracting noise levels when various participants were talking at the same time in the VR environment (e.g., during the poster session). Because of these aspects, and also the novelty of the system, some participants (7) argued that the VR experience *distracted* from the contents discussed in the class ("There was an issue with the noise, it was distracting", P5, man; "Having everyone around was distracting", P10, woman; "It is not the right tool to convey information,

people get distracted", P16, woman). In contrast, one participant argued that being detached from the physical environment while wearing the headset (e.g., not being able to check her phone) helped her to focus better on the class.

Taking into account these limitations, as well as cybersickness and comfort issues after prolonged use, most participants (18) considered that social VR platforms can be beneficial for learning activities involving higher level of interaction for a relatively short duration, and a relatively low number of participants (e.g., meetings of about five students in working groups) but they are not optimal for activities involving mostly one-way communication and complex or information-rich content ("I really liked VR for group discussions, like discussing in small group with the teacher", P3, woman; "I would prefer VR for everything but theoretical lectures", P12, man).

4.2. Social presence and social interaction

The second RQ addressed whether social VR enhanced feelings of social presence, and how social VR affected social interactions in the class, as compared to other options like videoconferencing or traditional FtF classes.

4.2.1. Social presence

Almost all participants (20) reported strong feelings of social presence (*being there with the others*) while using the VR classroom ("The distance just disappears", P1, woman; "You really get a feeling of being together in the same space", P16, woman). Those feelings were facilitated by the communicative affordances of the medium, particularly the ability to walk around in the VR space and approach others ("You can walk to people and say hi", P15, woman), and the realistic behavior of the VR environment, including the spatialized audio ("The sound is like in reality, the change of perspective when you look around, the hands movements... all these things together gave me that feeling", P6, man). Thus, affordances facilitating feelings of spatial presence also had an impact on experienced social presence. In addition, the type of task students were conducting also determined their level of social presence: various participants (8) agreed that tasks involving more social interaction (such as visiting a VR world together or visiting different posters during the poster session) elicited higher levels of social presence than less interactive activities (e.g., attending a lecture together in VR).

Several participants (9) stressed that feelings of social presence

contributed to making the learning experience vivid and enjoyable ("The presence of the other students around you; I really enjoyed that", P4, woman). Participants also reported that the sensation of social presence enhanced their connection with others ("socially and emotionally closer"; P5, man). One participant said that the seeming co-presence of her team members made her feel less nervous during the poster presentation. Another participant, however, reported that the presence of others was overwhelming and distressing, since she felt that others came *too close* to her.

4.2.2. Comparison with videoconferencing: naturalness of communication and social interactions

Many participants (14) stressed that interactions in VR feel more *natural* than in videoconferencing applications (like Zoom) and are even, to a certain extent, comparable to FtF interactions ("It's like actually speaking FtF"; P3, woman; "It felt close to being FtF", P6, man). Students stressed that VR allows for behaviors that mimic those in the real world, like just approaching and talking to specific others instead of, for instance, always talking to the whole group in a Zoom session or a text-chat ("In VR you can just walk to someone and talk to just a person; you don't need to say it to the whole class, like in Zoom", P11, woman). Students also mentioned that the spatialized sound and the ability to observe the others' nonverbal behavior (e.g., head and hands' movements of the avatars, blinking) made them perceive the communication in VR as natural.

Participants frequently used terms like "more personal", "closer", or "freer" to describe interpersonal communication in VR as compared to videoconferencing. Several students highlighted (10) that the similarity of VR to personal FtF interactions facilitated more "casual" and "informal" interactions, as opposed to the more hierarchical interactions on Zoom, where only one person can speak at the same time ("It was like the first day at school", P5, man; "I had a schoolyard feeling", P9, woman; "I wanted to say 'high five' to the classmates", P4, woman). This authenticity made two students even doubt whether a certain interaction had taken place in the physical world or in VR ("I had discussed something with a classmate in VR, and then we talked about the topic again in Zoom. I thought we had talked about it in real life, but it was actually in VR. It just felt so real there", P20, woman). However, at the same time there was general agreement that VR interactions are still far from reaching the quality of real-world interaction ("In the real world you feel more connection", P18, man). Participants criticized the lack of facial expressions, missing body-language cues (e.g., avatars' legs are not visible on AltspaceVR), the unrealistic appearance of cartoon-like avatars, and the fact that the others' actual faces were not visible. In summary, while students experienced the social interaction in VR as more natural and informal than in videoconferencing, they also argue that it falls short of personal FtF interaction.

Interestingly, some participants (5) believed that the feeling of presence and the more natural communication in VR (as compared to videoconferencing) facilitates involvement and participation in the class ("In Zoom it's easy not to participate at all, people just turn off the camera. In VR you feel more present, you feel the 'necessity' of participating in a discussion, it is harder to avoid interacting with others", P12, man; "You feel more self-aware in Zoom"; P3, woman; "In VR it feels more informal, and people tend to be more interactive", P13, man). At the same time, the sense of informality in VR (together with the novelty of the environment) led participants to experience the VR sessions as less structured and more colloquial than a normal class ("The atmosphere is more chill in VR", P5, man), and some (3) pointed out the need for a clear and explicit "etiquette" on how to behave in the virtual space before the class.

Given these specific benefits of VR as compared to videoconferencing, but also the technical limitations of VR (see section 4.1.1), most participants (18) agreed that they would prefer VR for interactive activities with a relatively short duration (e.g., workgroup meetings), but that videoconferencing works better for activities involving a more

unidirectional communication, when students needed to take notes frequently, and for longer sessions (e.g., traditional lectures).

4.2.3. Avatars

Avatars emerged as an essential aspect to understand social interactions in the VR classroom. A large majority of students used terms like "weird", "awkward", and "strange" to describe the initial impressions they made when interacting with the (cartoonish) avatars of others ("Feels somehow like seeing others in real life without actually seeing them in real life. Feels real, but you know it is not real", P4, woman; "It feels like seen them in real life, without seen them in real life", P3, woman). Students also reported uncertainty about how to use their own avatar and how others would perceive them ("I know how to represent myself better in real life, but I don't really know how to present myself in VR, I don't figure out how people see me in VR", P21, man; "I had to get used to using my own body language in VR", P2, man). For several students (10), however, these impressions faded with more experience, and the avatar-mediated interactions soon felt more natural ("When you get used to it, it's almost the same as in real life", P22, woman).

Students (with only one exception) designed their avatars to make them recognizable, trying (as much as possible with the system options) to make their avatars look like themselves. Many of them (11) highlighted that they were also able to recognize their classmates from their avatars. In some cases, since the students did not have many opportunities to interact with others FtF, some of them even reported that, when thinking about some of their classmates, they rather thought of the classmates' avatars than their actual faces. Various participants (7) stressed that mentally matching the image of the avatar and the real image of the others facilitated social presence, or made the interaction feel more realistic or of better quality. Thus, knowing the other person behind an avatar, and even recalling one's natural appearance, played an important role for most of the participants.

Some participants (6) also reported feeling "protected" while being embodied in an avatar when interacting with others: "I would be a little bit less shy in VR [than in the real world]" (P9, woman); "It's less scary to make a presentation in VR than in real life; people just see your avatar, not yourself" (P11, woman). For some participants (10), the use of avatars also contributed to making the classroom more informal and casual than a classroom setting in the real world (e.g., because of the teachers being represented with cartoonish avatars).

An important drawback, as expressed by most participants (20), was again the lack of expressions in the avatars' faces (potentially matching users' real facial expressions), which made it harder to emotionally connect with others and was perceived as disturbing in some cases: "I think even though it is responsive, it is still not responsive enough. You still do not know whether someone is actually participating or not and how engaged they are in the VR [...]. I think that can make you be less responsive yourself" (P12, man). However, a few (3) also pointed out a positive side of the fact that the others' actual emotions do not show in their faces, for example during the poster presentation: "People looking at you in real life makes me nervous, in VR is just the avatar and that makes doing a presentation easier because you cannot see if the audience is bored. You don't see their faces; you are not distracted by what the audience may think. The avatars always look happy" (P20, woman).

4.3. Effects on connectedness and feelings of community

Our third research question addressed how VR platforms may affect students' perceived connectedness and feelings of community in the class. The majority of the interviewees (19) highlighted a positive effect on feelings of community. For one group (9) this effect was not very intense, but for others (10), it was clear and pronounced ("You really get the feeling that you are a part of a class", P23, woman; "It definitely changed something about the bond between my classmates and me", P22, woman). The enhanced community feel was attributed to various factors, including the feeling of being in a shared space, that allows to sense the

social presence of others, but also forbids hiding (e.g., by turning off the camera, as many usually did on Zoom), and the perception that VR facilitates more natural and casual social interactions with other classmates (as compared to Zoom, see section 4.2.2). Another important factor in this context was the novelty of the technology, which stimulated joint activities like exploration (e.g., visiting together different VR worlds) and communal learning about how to use it (e.g., exchanging knowledge about details on how to perform actions in the VR environment).

Despite the enhanced feelings of community, the majority (15) did not think that the use of VR in the classroom impacted their overall feelings of loneliness or well-being. The most common explanation for this was that either participants did not feel lonely during the pandemic or that the use of VR was too short overall to impact how they felt. However, a smaller group of participants (8) reported some positive effects on feelings of loneliness, either because of the illusion of leaving their home ("It contributed to the feeling of not being only at home studying in your room. It makes you feel like you are going somewhere"; P11, woman) or because of the casual chat with other students sparked in VR ("I do not really meet many people right now with the pandemic, and I noticed that I really enjoyed random conversations with my classmates"; P5, man). Interestingly, two students also mentioned that social VR had an unexpected negative impact on their perceived loneliness, because in VR the contrast between those students who know each other already and mingled in a group and themselves, who did not, became apparent.

5. Discussion and conclusions

5.1. Enhanced social presence in social VR

The overall objective of this study was to assess how social VR technology can contribute to improving the social aspects of online education in a context where FtF education was not possible because of lockdowns during the covid-19 pandemic. Our results show the potential of social VR to increase social presence and feelings of community among students. They also reveal some of the mechanisms by which this occurs, including the illusion of physical co-presence (i.e., being located in the same space), naturalness of interaction (e.g., being able to move around the space and greet a peer; being able to use gestures, etc.), the possibility of performing actions together (e.g., exploring the virtual space), spatialized audio, and recognizable avatars (i.e., being able to easily identify classmates). At the same time, the poor facial expression of avatars (e.g., in terms of emotions) poses a barrier that limits the sense of social presence. These insights resonate with classic theories of computer-mediated communication, such as social presence theory (Short et al., 1976). Social presence theory proposes that social presence is a function of two factors: immediacy ("the psychological distance between the communicators"; Oh et al., 2018) and intimacy ("the feeling of connectedness that communicators feel during an interaction"; Oh et al., 2018). Some of the aspects reported by our participants, such as the illusion of spatial presence and the spatialized audio in social VR seem to contribute to the feeling of immediacy, therefore leading to increased perceptions of social presence. Others, like recognizable avatars, may contribute to intimacy (with familiar peers). In turn, limited facial expressions may hinder intimacy, keeping levels of social presence below those experienced in FtF interactions, as pointed out by our participants.

Our results also align with theories that have addressed social presence in online education, such as the Community of Inquiry framework (Garrison et al., 1999). In this approach, social presence in learning is characterized by three factors: open communication, group cohesion, and emotional expression. Our results suggest that, among these factors, social VR technologies may facilitate open communication (through a more natural and FtF-like form of interaction, as compared to videoconferencing) and group cohesion (through the possibility of performing activities together). Again, the poor facial expression of avatars would limit the capacity for affective expression, making social presence in VR more limited than in FtF meetings.

Despite this limitation, our results suggest social VR technology might foster social interaction beyond what videoconferencing can offer, which could have clear benefits for students learning. Social interaction is considered a central component of learning in numerous theoretical approaches (e.g., social constructivism, social cognitive theory, or connectivism; Adams, 2006; Scavarelli et al., 2021). More specifically, social presence is one of the aspects that determine a successful educational experience (Garrison et al., 1999). It is important to note that social presence may not only contribute to interactions between students but also to those that occur between students and teachers. The physical co-presence of the teacher and the more casual or informal environment reported may help to perceive teachers as more approachable, easing student interaction with the teacher. Previous research shows that the immediacy of the instructor has a positive impact on learning (Arbaugh, 2001; Baker, 2004), and fluid contact between students and teachers is considered a key good practice for educational success (Chickering & Gamson, 1987). Therefore, social presence in VR could also involve benefits in this respect. In addition, feelings of social presence could also positively impact student motivation. Research on self-determination theory underscores that the need for relatedness (e.g., meaningful connections with others) contributes to students' intrinsic motivation in the educational experience (Ryan & Deci, 2020). Given that social presence in VR enhances feelings of relatedness with other users (Barreda-Ángeles & Hartmann, 2022; Turk, Heddy, & Danielson, 2022), social VR technology could also have a positive impact on student motivation. However, these questions were not directly addressed in our study and merit empirical analysis in future research.

Some previous research had already suggested the potential of social VR to increase social presence in online education and its potential impact on community feeling (e.g., Ripka, Grafe, & Latoschik, 2020; Seufert et al., 2022), but with very small samples of participants, and short periods of use. Our study contributes to confirming these results with a larger sample of participants (35 students in the class, of which 23 participated in the interviews) and over a more extended period (six weeks). Yet, our study also explored new aspects that only become apparent in large groups of participants, and in prolonged use. Firstly, difficulties appear in large groups that are not obvious in smaller groups, such as the problem related to noise because of multiple users speaking at the same time or specific technical problems (the poor visibility of the screens in VR when the participant's avatar is more remote due to a larger crowd). The larger sample also helped to reveal issues that, even though they occur among a minority of the participants, may be relevant. For example, although social presence was appreciated by most students, a few students perceived certain negative aspects of feeling of co-located with others, like that others felt "too close" or that they became painfully aware that others, in contrast to them, already (spatially) mingle in groups. In a similar vein, while most students reported some positive effect on feelings of social connectedness and community, several did not perceive that the present VR classes significantly impacted their overall well-being or feelings of loneliness during the lock-down, suggesting that the potential benefits of such social connectivity are rather limited beyond the classroom.

Taken together, these findings suggest that while VR has potential, the increased social presence produced by VR does not necessarily always result in a better learning experience for all learners. In this respect, approaches to mediated communication, such as the Differential Susceptibility to Media Effects Model (Valkenburg & Peter, 2013), underline the need to understand the individual antecedents that may determine different media effects for different users. This perspective should be considered when investigating the experiential effects of social VR which, as our results show, may vary significantly among students.

Prolonged use of social VR technology over time also reveals facets of the participants' experience that have a temporal evolution and are not obvious in studies of shorter duration. These include the disappearance of cybersickness that was initially experienced by some participants after a few sessions. Another relevant aspect in this context is the evolution of

the perception of the avatars and their use over time. They were first perceived as "awkward" while students afterwards habituated and responded more naturally to them. Thus, the greater naturalness in communication that is facilitated by avatars (which, as mentioned above, contributes to social presence) is only reached, for many participants, after some habituation period, which is unlikely to be captured in studies of very short duration.

These new insights contribute to a more refined view of the role of social presence in VR-based distance education, and motivate future, more refined analyses about the specific circumstances in which social presence, elicited by social VR technology, may be most beneficial.

5.2. Integration of social VR in education

Our results provide ideas for better integration of social VR in educational projects in higher education, beyond its impact on social presence. First, we highlight the need to assess in which specific scenarios social VR can have advantages that outweigh its disadvantages. With the current state of technological development, social VR seems particularly suitable for relatively short sessions where interaction between participants is essential, such as group work sessions or tutorials with teachers. For these types of activities, the advantages of social VR, particularly if it is easy to apply, like the present application, are evident. In contrast, in activities such as traditional lectures, the disadvantages may outweigh the advantages.

Although using the technology does not present major technical problems (and VR is valued by the students as a tool with potential), factors like the weight of the headset and the poor resolution of screens inside the VR environment were two important limitations. This stresses the convenience of providing students with detailed information on the ergonomic aspects of the headsets (e.g., the correct way to put the straps on the head and lens adjustments for proper visibility) to minimize discomfort. The lack of note-taking tools was another key limitation of the system used in our study. However, the technology is advancing rapidly, and systems have already appeared during the period of this study that alleviate this and other limitations mentioned above (e.g., applications that allow note-taking, such as Meta Works or Spatial.io; a lighter weight of the equipment and better visual resolution in more modern headset models). Other limitations, such as the high prevalence of cybersickness, may perhaps be harder to overcome. Although most students reported that cybersickness tended to fade as they became more accustomed to VR (which also matches previous findings in the literature on cybersickness; Gavgani, Nesbitt, Blackmore, & Nalivaiko, 2017), for some, it persisted across sessions, particularly when they were long. Therefore, the possibility of employing desktop versions in the most persistent cases of cybersickness should also be considered when implementing social VR educational tools.

Another crucial aspect that emerged in our results is the role of avatars' features in fostering social interaction and feelings of community. The absence of facial emotions and, in some cases, the lack of similarity between the avatar and the real person, pose barriers to the development of richer and more natural social interactions. However, recent technological advances might soon help overcome these limitations. For example, there are already devices that can track user's facial expressions and incorporate them into the avatar in real-time (<https://www.vive.com/eu/accessory/facial-tracker/>), as well as tools to create more realistic avatars (e.g., www.spatial.io; www.readyplayerme.com; www.didimo.co). Teachers intending to use social VR platforms in their classes should also take this aspect into account when considering different platforms.

Beyond the technical aspects, another factor that requires attention is the cognitive load that the VR experience places on students. Many participants mentioned that the VR classroom was distracting and could make concentration difficult. Beyond the aforementioned technical limitations, social VR could pose an extra cognitive load for students that could hinder the learning process. Previous research (Ahn, Nowak, &

Bailenson, 2022; Barreda-Ángeles, Aleix-Guillaume, & Pereda-Baños, 2021), inspired by the Limited Capacity Model of Motivated Mediated Message Processing (Lang, 2006), suggests that the experience of *being present* in a virtual environment has a cost in cognitive resources, which negatively affects the recall of the presented content (e.g., compared to its presentation on a 2D screen). Moreover, social interaction in social VR could also have a cognitive cost: collaborative cognitive load theory (Kirschner, Sweller, Kirschner, & Zambrano, 2018) suggests that social interaction in collaborative learning places a cognitive load on learners (although the possibility of sharing information with other group members may help to alleviate that cost). Our research does not provide sufficient granularity to analyze how social VR affected the cognitive processing of content, but the fact that many participants found that they were distracted in the virtual environment underscores the need to address this question in more depth in future research on the topic.

Our results also point to some unexpected advantages that social VR may have over videoconferencing technologies for remote education regarding the cognitive load experienced by students. Some students mentioned that, by isolating them from their home environment and transporting them to a new (virtual) place, the use of VR helped them to concentrate on the content of the class. In this respect, as a medium that isolates users from the environment, perhaps social VR can contribute to minimizing problematic multitasking behavior (e.g., checking smartphones) during online courses (e.g., Lepp, Barkley, Karpinski, & Singh, 2019). Moreover, given the potential negative effects of prolonged use of videoconferencing tools ("Zoom fatigue"; Bailenson, 2021), the use of social VR could be particularly beneficial in courses that rely primarily on online (rather than FtF) interaction. Once the technical limitations of social VR mentioned above are overcome, these two aspects could also add value to the use of this technology. Thus, these two aspects clearly deserve further exploration in future research.

Another key aspect to understand the potential of social VR in education is to examine to what extent the positive effect on the feeling of connectedness and community that we have found may impact educational outcomes. To this end, future research should also quantitatively examine the impact of social VR on student satisfaction and performance, in different courses and topics. This question will be central to assessing the costs/benefits of a technology that is still relatively expensive and may require significant effort to be implemented in the classroom (Hamilton et al., 2021). Furthermore, responsible use of social VR in this context should also emphasize understanding the requirements of participants with special needs (e.g., students with visual or hearing impairments). In this regard, the Universal Design for Learning approach (Black, Weinberg, & Brodwin, 2015; Rose, 2000) may be particularly advantageous and deserves attention in future studies.

5.3. Limitations

As any study, also the present study was not free of limitations. First, we only examined one social VR platform, and hence we do not illuminate the potentially unique effects of different existing social VR platforms. Also, for practical reasons, the present study included only one group of students in a single course. Although the sample size and duration of the sessions were much larger than in other comparable research, the results obtained should be contrasted with other samples in future studies.

Our study did not analyze how social presence might benefit other VR applications or uses of VR beyond what we examined in the present study (e.g., in interactive simulations; Pottle, 2019; or in field-trips to places of interest; Fung et al., 2019). The combination of both dimensions (i.e., social interaction and interactive simulations/field trips) is where social VR can perhaps make the strongest impact. In addition, future work could examine how some of the negative effects noted by some of our participants (e.g., overwhelming social presence, or feeling socially excluded) could be overcome.

Another limitation of our study is the novelty of the technology,

which might foster both positive (e.g., excitement) and negative (e.g., usability problems) effects, and therefore also plausibly influenced the findings of the present study. Future research should analyze to what extent the present findings persist among users accustomed to social VR.

Finally, in future studies on using social VR in education, we recommend analyzing other aspects not covered in the present study, such as concerns about privacy that have been raised about VR (e.g., De Guzman, Thilakarathna, & Seneviratne, 2019).

5.4. Conclusions

There are still many questions to be answered in order to understand and assess the potential of VR in higher education, especially considering the constant and rapid evolution of this technology in recent years. However, in a world where online education needs are increasingly pressing (García-Morales, Garrido-Moreno, & Martín-Rojas, 2021; Strielkowski, 2020), and where social VR seems to grow into an important new candidate to support not only online but potentially also on-campus teaching (Brown, 2021; Rosedale, 2017), it is important to understand the advantages and challenges it can bring to higher education. Our results provide initial answers to these questions, and they might stimulate further research on this topic, by pointing both to the great potential of the technology and to clear challenges yet to be overcome.

Statements on open data and ethics

The participants were protected by hiding their personal information in this study. They were voluntary and they knew that they could withdraw from the study at any time. The anonymized data can be provided upon reasonable request by sending e-mails to the corresponding author.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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