Exploring User Experience and Design Opportunities of Desktop Social Virtual Reality for Group Learning Activities

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ABSTRACT

Conducting group learning activities (GLAs), e.g., group discussion and presentation, can improve course outcomes. But when GLAs are carried out online, they may face challenges such as a reduced sense of social presence. Social virtual reality (VR) that enables a group of people to interact in virtual space could better support social presence than the video conferencing systems commonly used for online courses. However, few works explore the use of social VR for online GLAs. In this paper, we conduct a co-design study with five small groups of students in an online course to investigate user experience and design opportunities of desktop-based social VR for GLAs. Participants experience a desktop social VR platform Mozilla Hubs in their group projects and use techniques like storyboarding and prototyping to propose new social VR designs to support GLAs. We contribute design ideas about social VR applications that support various kinds of online GLAs.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in collaborative and social computing**; *Field studies.*

KEYWORDS

Social virtual reality, desktop applications, group learning activities, co-design, user experience

ACM Reference Format:

Zhenhui Peng, Chuhan Shi, and Xiaojuan Ma. 2021. Exploring User Experience and Design Opportunities of Desktop Social Virtual Reality for Group Learning Activities. In *The Ninth International Symposium of Chinese CHI (Chinese CHI 2021), October 16–17, 2021, Online, Hong Kong*. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3490355.3490367

1 INTRODUCTION

Group learning activities, such as group quiz contest, discussion, and presentation, can generally improve students' collaborative learning outcomes in their courses [23]. For example, these activities can foster students' higher-order thinking skills [12] and help them develop collaborative skills [9]. However, it could be less effective to conduct these activities in online courses normally delivered via video conferencing systems (e.g., Zoom [33] and Skype [24]), which are widely used for their accessibility especially during COVID-19. For one thing, people in video conferencing systems could lack the sense of others' social presence, which would reduce performance in group projects [25]. For another, teachers and students can not customize the learning environment of these systems with shared space and objects that could bring convenience to the group learning activities.

Social Virtual Reality (VR) that enables people to interact with one another in a virtual space [22] is a promising alternative medium for conducting online group learning activities for its benefits of social presence support [19] and shared virtual objects. There are many commercial applications such as Mozilla Hubs [5], Anyland [15], VRChat [11], and Rec Room [13] that support experiencing social VR either through a headset device or a desktop/laptop computer. We focus on desktop social VR in this paper, because it is more accessible to a large number of teachers and students and causes less severe cybersickness symptoms to users in online lectures compared to the headset-based social VR [30]. Social VR has been used in virtual conference [8], online dating [31], medical consultation [16], and entertainment activities [13] that can benefit from its social presence support. Yet, few works have explored its usage in group learning activities that further requires a balance between students' productivity and their social experiences [18]. Little is known about students' experience of desktop social VR for group learning activities and what features of social VR they desire for conducting these activities in online courses. These are important questions to answer because the design and applications of desktop social VR for group learning activities are likely to improve the students' engagement and learning gain in online courses [9, 12].

To answer these questions, we conduct a co-design study with five small groups (e.g., 5 - 6 students per group) of university students in an online Human-Computer Interaction (HCI) course. Co-design [26] is a collaborative design approach in which stakeholders — such as researchers, designers, and users or potential users who are considered as "experts of their experiences" [29] – share their perspectives and cooperate creatively to generate new designs [27]. In our co-design study, students first gain firsthand experience of using desktop-viewing Mozilla Hubs for their group discussion and collaboration in two course projects. Then, each group is asked to review video recordings of their meetings in the Hubs to summarize user experience with the Hubs. After that, each group is encouraged to use HCI techniques, such as Mindmap, Storyboarding, Points

Chinese CHI 2021, October 16–17, 2021, Online, Hong Kong

ACM ISBN 978-1-4503-8695-1/21/10.
https://doi.org/10.1145/3490355.3490367

of View, and Prototyping, to analyze user needs and propose potential designs to improve the desktop social VR for supporting online group learning activities. Finally, all groups share, discuss, and refine their designs together in an 80-mins session. Our main contributions are twofold. First, we add to the understandings of user experience in online group learning activities with desktop social VR regarding its pros and cons. Second, we derive five design ideas to improve desktop social VR for supporting various kinds of online group learning activities. They can be used as a good starting point to extend the design space and usage scenarios of social VR in the educational domain.

2 RELATED WORK

2.1 Group Learning Activities

Group learning activities refer to curriculum activities in the learning process, in which students work on collaborative projects to achieve mutual goals [6]. In these activities, students can discuss their ideas, challenge each other's views, and work on their tasks collaboratively, which are considered effective in learning [23]. Despite the positive effects of group learning activities, lecturers and students may face challenges to conducting such activities in online courses, which become a main way of teaching during pandemics like COVID-19. For example, students may feel dissatisfied and frustrated in online learning groups as they may encounter difficulties in communicating with each other, coordinating group members, and ensuring group efficacy [4]. To facilitate online teaching, commercial companies have developed a lot of tools such as Zoom, Skype, and Google Hangout, to name a few [10]. However, these tools are mostly based on video conferencing systems in which users can see each others' faces in small grids but can not sense other social elements like distance to others and body movements as people do in offline group activities. Social virtual reality (VR) platforms could provide people more sense of presence compared to those video conferencing systems by allowing users to represent themselves by 3D avatars and interact in the virtual rooms. In this project, we explore the user experience and design space of social VR for supporting group learning activities.

2.2 Social Virtual Reality

Social virtual reality (VR) has been applied in various scenarios, such as virtual conference [8], online dating [31], and entertainment activities [13]. For example, social VR offers a space for couples in a long distance to conduct dating activities like embodied physical contacts and virtual wedding [31]. In educational scenarios, teachers can organize their courses in a virtual environment and invite students to join remotely [30]. Previous research has explored social VR designers' perspectives on their platforms' features [22], children's [20] and the older adults' [1, 2] experience with social VR, and design and experience of special features like avatars [7, 14] and photo sharing [17] in social VR platforms. However, most of them study headset-based social VR, which requires additional headset display devices and could be less accessible than desktop social VR when applied to a large scale of online courses. Yoshimura et al. collected students' experience with desktop- and headset-based social VR for online lectures [30]. They found that despite desktop social VR produces lower presence, it reduces sickness symptoms compared to the headset one [30]. Yet, little is known about students' experience with and desire for desktop social VR especially for group learning activities in online courses, which are our focus in this paper.

3 METHODS

To explore user experience with desktop social VR for online group learning activities and ways to improve such experience, we conduct a co-design study with 29 students (12 females, 17 males) in an online Human-Computer Interaction (HCI) course of a local university. They form five small groups (G1 - G5) with five or six members and at least one female and one male per group. All of the participants major in Computer Science and are undergraduates (ranging from 1st- to 5th-year). We obtain their consent at the beginning of the course for taking part in a co-design social VR project which can exercise their HCI skills such as empathizing, ideating, and prototyping. We use the social VR platform Mozilla Hubs as it supports desktop viewing and has been used in online lectures [30]. In Mozilla Hubs, users can create and join their groups' virtual rooms displayed on the computer screen, represent themselves by customized avatars, move around the rooms using keyboards and mouses, add materials like 3D objects and videos to the rooms, share computer screens, take photos, and chat with others via voice, text, or emoji. At the beginning of the course, the instructor gives an online lab tutorial about how to use desktop Mozilla Hubs.

Phase 1: Experiencing desktop social VR for group learning activities. In this phase, participants will experience desktop Mozilla Hubs in two additional group projects about designing an online communication tool and Human-Robot Interaction for course credits. Each project lasts for three weeks and requires each group to discuss the assigned topic, propose a design on this topic, make a video prototype, and present and discuss their designs in the course. During these projects, participants are asked to conduct weekly group meetings in Mozilla Hubs to discuss their ideas and prepare for the presentation.

Phase 2: Cooperatively proposing designs of desktop social VR applications to better support group learning activities. The third course project about the co-design social VR for online group learning activities comes right after phase 1. In this project, each group needs to first summarize user experience with social VR by reviewing their meeting records in Mozilla Hubs. Then, each group is required to propose a design of desktop social VR applications to better support group learning activities. In this process, participants are encouraged to cooperate creatively with their teammates using HCI techniques like Mindmap, Storyboarding, Points of View, Hierarchical Task Analysis, and Prototyping (Fig. 1).

Phase 3: Presentations and discussions on the proposed designs. At the end of the co-design social VR project, all participants join an online Zoom session of presentations and discussions on each group's proposed design. The session lasts 80 minutes and is moderated by the authors of this paper. Each group has around 10 minutes to present its experience with Mozilla Hubs, design process, and video prototypes. After each presentation, instructors or audience from other groups will give comments and ask questions to refine the proposed design together for about five minutes.

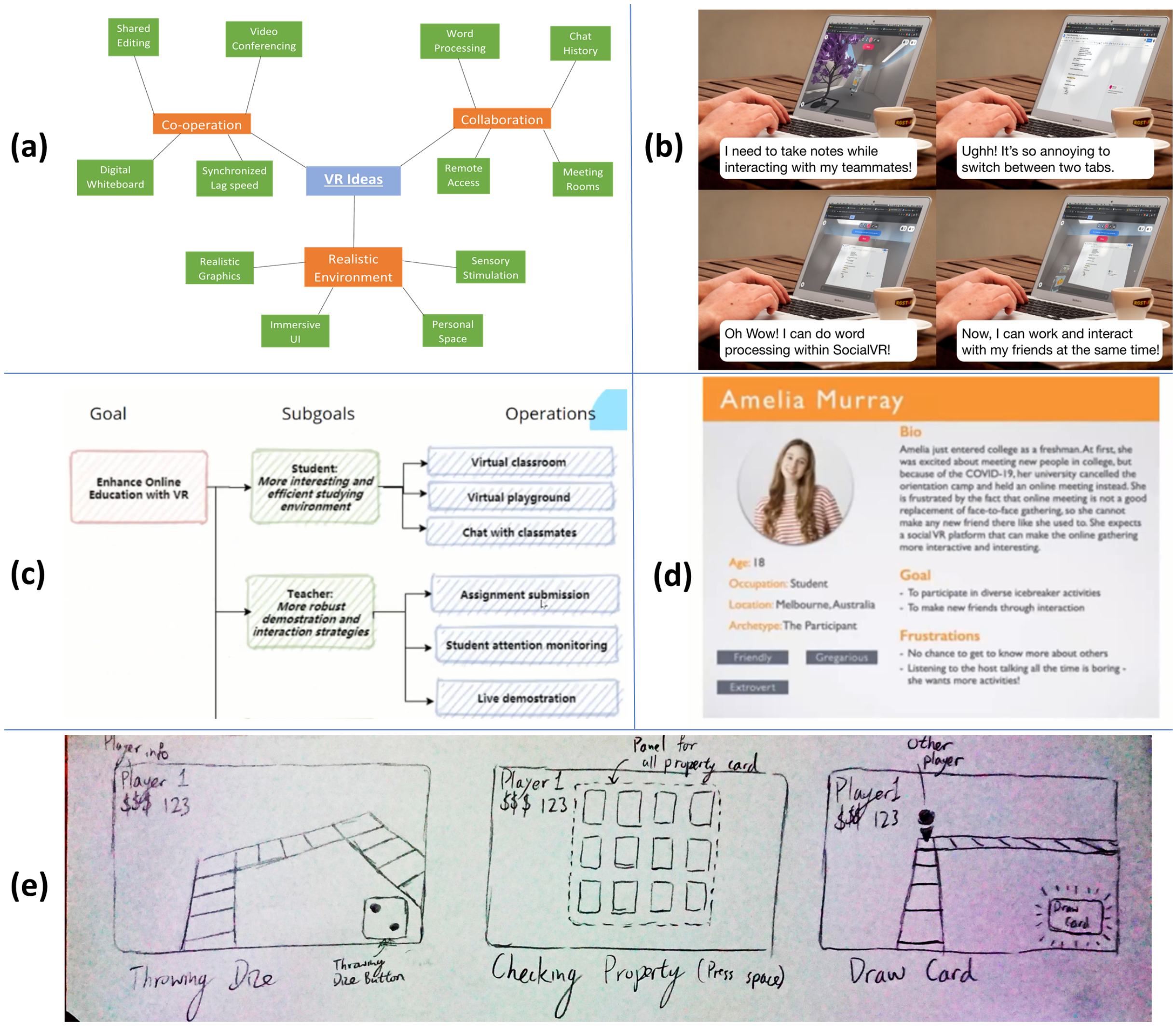

Figure 1: Example of HCI techniques used in participants' co-design process: a) Mindmap (G3); b) Storyboarding (G3); c) Hierarchical Task Analysis (G1); d) Points of View (G5); e) Paper prototype (G1).

We use a thematic analysis [3] approach to examine the collected presentation slides and responses of each group to the audience's questions. Two authors first independently familiarize themselves with the materials and group the reported user experience and proposed ideas of desktop social VR each in potential themes. They then meet and discuss together with the HCI course instructor who helps to finalize themes regarding the pros and cons of desktop Mozilla Hubs user experience and the types of group learning activities that each proposed idea support.

4 RESULTS

In this section, we present the co-design outcomes about user experience and design ideas of desktop social VR for group learning activities.

4.1 User Experience with Desktop Social Virtual Reality

Table 1 shows the user experience of desktop social VR reported by our five groups (G1, 2, 3, 4, 5). Four groups explicitly mention that the Mozilla Hubs provides them a sense of presence for group learning activities. However, G1's members comment that they do not know whether the avatars staying in a position are focusing on the group activities. The Hubs' interaction features like screen sharing and photo taking are helpful for group learning activities, as appreciated by G1. Nevertheless, the Hubs does not link well to external software, especially those (e.g., Word and Excel) important for productive group collaborations, as reported by G3 and G4. In terms of the generic features of Mozilla Hubs like its visual design, G2 and G5 feel that its functional icons are generally consistent. Yet, G2 would expect that there are annotations near the icons explicitly

	User Experience of Desktop Social Virtual Reality	
	Pros	Cons
Sense of presence	Simulated presence in face-to-face experience (1, 2, 4, 5)	Do not reflect if others are focusing on the interaction (1)
Interaction features	Screen sharing (1); Picture taking (1)	Not link well to external software, e.g., Word, Excel (3, 4); Easily unaware of current speakers (4); Unable to record users' activities (e.g., annotation) in the environment (5)
Visual Design	Toolbar icons on the top are consistent (2, 5); Avatar's expression of personal action is natural (4); All features are consistent among different scenes (5)	The icons' functions are not clear enough (2); Navigation and orientation support is not good (4); Objects should not overlap with each other (5)
Customization of virtual environment	Can add customizable objects (1); Able to manipulate personally created objects via options mute, size, etc. (5); Able to customize scenes and avatars (5)	Can not delete others' shared objects (3); Unable to redo or undo an action on the objects (5)

Table 1: User experience of Mozilla Hubs in desktop-based viewing reported by five groups (1, 2, 3, 4, 5) in the study.

indicating their functions, and G4 would want more navigation and orientation support in the social VR environment. The objects in the Hubs are able to overlap with each other, which is a concern for G5. Lastly, our groups in the study like that they can add customizable objects to the virtual rooms (G1), can manipulate the objects created by themselves (G5), and can customize the room's scenes and avatars (G5). However, G3 says that they can not delete others' shared objects, and G5 mentions that they are unable to redo or undo an action on the objects, which could make the customization of the room less convenient.

4.2 Design Ideas to Improve Desktop Social Virtual Reality for Group Learning Activities Online

Table 2 summarizes the proposed design of desktop social VR applications for supporting group learning activities. In this work, we attempt to present a broad range of possibilities proposed by our participants to support effective group learning activities in desktop social VR. We hope that this paper can inspire further research that expands, critiques, or challenges these ideas.

G1 - Competitive learning activities inside the group via board games. G1 targets the competitive learning activities (e.g., debate and mutual quiz test) inside the group and proposes to improve such experience via board games in desktop social VR. This group demonstrates its ideas in a Monopoly board game (Fig. 2a), in which members throw dice to move and may encounter battles against the others in certain positions. Members in G1 argue that board games can encourage online social interaction similar to that in offline settings. Teachers can pre-set questions or topics of a debate that test the course knowledge in these battles or let the students create their own content of the battles.

G2 - Augmented features for collaborative group activities. The targeted users of desktop social VR in G2's design are the hosts and group members. This group presents a set of features to help users conduct collaborative group activities in social VR. For example, to moderate group presentation, G2 builds a stage for the host and presenters and seats for the audience, and the host can invite the presenters via a pop-up window in the virtual room (Fig. 2c&d). G2 also designs a feature of a marked chat circle that could give each group a private space for conversation. Furthermore, the host can conduct an engaging group quiz competition using the features of a leader board and pop-up questions.

G3 - Collaborative word processing via editable applications in VR environment. As mentioned in Table 1, the main concern of G3 of Mozilla Hubs is that it does not link well to external software like Word and Excel. G3 proposes to address this concern by incorporating multiple screens with editable applications in the virtual environment (Fig. 2b). This group suggests that the desktop social VR should enable sharing multiple screens of the user's computer at the same time, such that the group members do not need to switch the applications back and forth. For example, the group can put a screen that displays an editable document next to another screen that displays a slide so that the members can view them together. The group members can further edit the shared document together using annotation tools of the social VR platform.

G4 - Chatbot for moderating group presentation. G4 specifically focuses on the group presentation scenarios. G4 proposes to use a chatbot to moderate the group presentation process (Fig. 3a). As argued by G4, the chatbot can reduce the host's workload of arranging the speakers' order and keeping the time during the presentation. It displays the name of the speaker in the VR environment, which could help people be aware of who is going to speak.

G5 - Simulated group learning activities in virtual classrooms. G5 builds up a virtual room that has desks and chairs similar to those in the offline classrooms for each student (Fig. 3b). This group believes that students can easily get familiar with such a virtual space for group learning activities and can quickly adapt to

Figure 2: (a) BoardgameVR proposed by Group 1 – battles with each other in certain positions. b) Collaborative word processing in social VR environment proposed by Group 3. (c & d) Augmented features of desktop social VR proposed by Group 2 for collaborative group activities: c) presentation; d) marked chat circle and quiz contest.

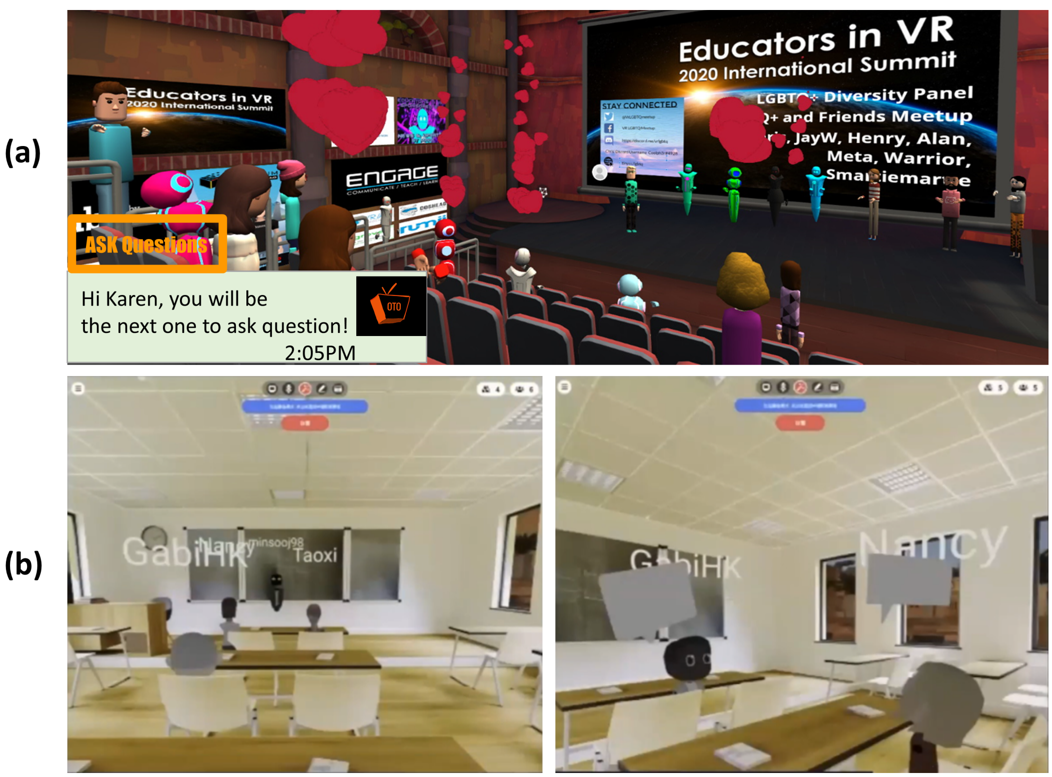

Figure 3: a) Chatbot for moderating group presentation in social VR proposed by Group 4. b) Simulated virtual classroom in which lectures can organize group activities like offline contexts proposed by Group 5.

Group	Supported group learning activities	Proposed ideas
1	Competitive learning activities inside the group, e.g., debate and mutual quiz test	BoardgameVR, e.g., Monopoly with elements of competition and quiz
2	1) Group presentation; 2) Group discussion; 3) Group quiz competition	1) Unique options for the host; 2) Marked chat circle; 3) Leader board and pop-up questions
3	Collaborative word processing	Projection of editable applications on multiple virtual screens
4	Group presentation	Chatbot for arranging orders and time-keeping
5	Group presentation, discussion, and quiz contest	Virtual classrooms with desks and chairs

Table 2: Proposed ideas for supporting online group learning activities.

such experience when resuming face-to-face lessons. In this classroom, students sit in their chairs, and the lecturers can manage the online group activities as they do in offline contexts. For example, they can invite each group to present their ideas in front of their classmates, and they can ask students to discuss a topic with each other nearby.

5 DISCUSSION

From our co-design findings, we derive several design considerations for improving desktop social VR for online group learning activities regarding sense of presence and productivity features.

Improve sense of presence by projecting users' non-verbal expressions on avatars. The sense of presence is the main strength of social VR for online group learning activities, as explicitly mentioned by most of our participants (Table 1). Previous researchers have tried to use trackers to track users' facial expression and body movement to facilitate non-verbal communication in headset-based social VR contexts [21, 28]. However, in desktop settings of Mozilla Hubs, users can only convey limited non-verbal expressions such as controlling proximity and body orientation through moving the avatars and sending emojis. We suggest that designers of social VR platforms could develop more features for desktop users to conduct non-verbal communication. For example, the platforms can provide an option for users to turn on webcams and map their facial expressions to the avatars [32]. They can also provide keyboard shortcuts that link to specific body actions like waving, nodding, and clapping, which could indicate that the avatars are greeting, listening, and focusing on the interaction.

Improve group productivity by adding group coordination features, linking to office software, and offering template environments of group activities. Productivity is important for a group's success especially in collaborative activities [4]. Our participants propose a set of features that could improve the productivity of group learning activities from different aspects. For example, G2 proposes an "invite to speak" feature and a leader board (Fig. 2c&d), and G4 proposes a chatbot for the host to effectively coordinate the group activities (Fig. 3a). G3 presents its design of collaborative document processing with multiple shared screens displaying office software in the virtual space (Fig. 2b). While current social VR platforms like Mozilla Hubs offer various types of objects for users to customize the environment, the design and development of such productivity features by users could be time-consuming. To reduce users' workload in customizing a productive environment, we suggest that social VR platforms could incorporate existing productive software (e.g., Word and Excel) into the virtual space and offer functions for users to edit the documents together via keyboard and mouse inside the space. The platforms could further offer more template environments specific for different group learning activities, e.g., a virtual classroom for group discussion (G5) and a conference hall for group presentation (G4).

5.1 Limitations and Future Work

As a preliminary exploration, our work has several limitations. First, our study is of a qualitative nature to have a more in-depth understanding of the user experience of desktop social VR and to propose design ideas for its usage in group learning activities. We do not carry out a quantitative comparison of the pros and cons between the desktop social VR and headset-based social VR or video conferencing system. Second, our participants in the co-design study are undergraduates, which can not reflect the experience and desire of other types of users such as primary and high school students. Third, participants only experience group discussion and preparation of presentation in Mozilla Hubs, and based on that, they propose designs of social VR for supporting any type of group learning activities. Future work can extend the proposed design ideas of desktop social VR and evaluate them with diverse users.

6 CONCLUSION

This paper provides findings on user experience and design opportunities of desktop social virtual reality (VR) for online group learning activities. Via a co-design study with five small groups of university students in an online course, the results show that participants appreciate the sense of social presence supported by desktop social VR and expect more features like linking to external productivity software. We further present five design ideas of our participants and discuss design considerations to improve desktop social VR for online group learning activities. Our work has practical insights for designers and users of social VR.

ACKNOWLEDGMENTS

This work is supported by the Research Grants Council of the Hong Kong Special Administrative Region, China under Grant No.: T44-70716-N.

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