Article

Experiences of a virtual think tank. New ways of working, knowledge development and Virtual Reality events

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Received: 21 October 2022
Accepted: 15 November 2022
Online: 30 December 2022

Abstract. Virtual Reality (VR) as a paradigm for casual communication and socialising is seeing increasingly high adoption rates, but since the pandemic it also sees consideration as an alternative environment for (remote) knowledge work. This study explores VR as it relates to knowledge development at scale (i.e., conferences/events), to identify barriers for adoption. The study consists of observations of a series of VR and videoconferencing events, interviews with organisers and participants, and a survey of participants. Elements of Extended Adaptive Structuration Theory were used to examine results, focusing on technological, social, and performance dimensions.
Results show no clear technological obstructions for events' outcome quality compared to conventional forms of remote collaboration. VR provides practical advantages involving non-verbal communication and immersion/presence over conventional alternatives, but lacks in other aspects (e.g., facial expressions). Organisers are still learning to work around the practical limitations of VR. Issues raised primarily relate to technology habituation, or to social interactions and the cultural coordination gaps stemming from a lack of (communication) agreements. Emphasising the advantages of VR while further developing technologies and thoughtful social conventions to alleviate the objections will further open the door to VR as a viable alternative for remote work.

JEL: D830.
Keywords: virtual collaboration; knowledge work; virtual reality; VR; virtual events; remote work.
Citation: Vitalija Danivska, Wouter Van Tankeren (2022) Experiences of a virtual think tank. New ways of working, knowledge development and Virtual Reality events. – *Applied Business: Issues & Solutions* 2(2022)10–17 – ISSN 2783-6967.
https://doi.org/10.57005/ab.2022.2.2

Introduction

The Covid-19 pandemic and worldwide lockdowns have forced employees to adopt to new ways of working, in many cases, leading to more remote work. The European Centre for the Development of Vocational Training [1] says that, according to early evaluations, 40-70% of active workers are a ected by remote work compared to 15-17% before the pandemic. This shift has forced organisations to adopt various technological solutions to better accommodate geographically distributed working. Thus, knowledge sharing and -creation moved largely to digital/virtual places. By now, employees are somewhat comfortable using collaboration tools like *Teams*, *Zoom*, and *WebEx* for online meetings, -conferences, and sharing information virtually.

For many employees, remote work led to increased flexibility, better work-life balance, or even increased job satisfaction [1-3], therefore, less willingness to go to the o ce every day of the working week after the pandemic [5-6]. However, remote work also brought more negative experiences to some. For example, constant videoconferencing reduced the wellbeing of employees leading to an increased emotional exhaustion [7], fatigue [8] or creating higher psychological demands [9]. Moreover, research by Yang et al. [10] shows that collaboration became more siloed and static potentially a ecting transfer of knowledge and quality of employees' produced outcomes.

Research also suggests that remote work creates challenges for employees such as work-home interference, ine ective communication, procrastination, and loneliness [11]. Nonetheless, many agree that remote work practices are here to stay, and the attention should move towards making remote work more e ective. For example, Bennett et al. [12] provide an evidence-based list of suggestions on how to improve online meetings whilst Orel [13] suggests looking into alternative technologies, such as extended realities (XR) that could help to overcome those known challenges.

In this article, we explore how people experience fully remote collaboration by using di erent tools and approaches to remote work. We emphasize the experience with virtual reality (VR) environment due to the lack of research in the field and the potential for further studies. With this study, we aim at (1) better understanding of a potential for virtual reality (VR) technology to be used as a substitute/additional platform for (remote) knowledge work and collaboration, and (2) identifying factors/requirements from user perspective that need to be addressed by organisations in order to implement VR technology for remote work.

1. Theoretical overview

We are living in a world driven by knowledge, information, and innovation capabilities [14]. Innovation is not possible without social interactions, communication, and collaboration which are seen as salient factors a ecting organisations' capabilities to successfully innovate [15].

Collaboration becomes even more important when we talk about knowledge work, the type of work that requires manipulating knowledge and information [16]. As it is less structured and more iterative, organisations often expect that teamwork, co-location and knowledge availability can improve collaboration and, consequently, innovation in organisations [16]. Collaboration is defined as "the act of working with another person or group of people to create or produce something" [17] and success of it depends on multiple

Table 1. Determinants of virtual team success. Adapted from Naik and Kim [21].

Structures	Categories	Components
Structural characteristics	Organisational dimension	culture, structure, training
	Task dimension	generation, choose, negotiate
	Technology dimension	immediacy of feedback, social presence, parallelism, multiplicity of cues
	Team dimension	culture, awareness
	Individual dimension	personality, knowledge
Control structure	Mission	complexity
Social interaction	Emergent socio-emotional states	trust, shared understanding, conflict, cohesion
	Decision-processes	communication, coordination, collaboration, conflict management
Outcomes	Performance	solution quality, time
	Satisfaction	solution satisfaction, virtual experience

factors. The common factors a ecting collaboration can be divided into contextual factors, support, tasks, interaction processes, *Teams*, individuals and other [18].

Collaboration in management studies is often understood as a process towards a common goal and emerging from the interactions of people with emphasis placed on communication process and interactions [19]. With increasing remote work practices and people not being able to meet face to face, those interactions changed as well. For example, a study by Yang et al. [10] noticed that people changed communication channels (more usage of instant messaging (IM) and emails) and times of communication (more dispersed hours, more asynchronous communication) as well as who they communicate with (less new connections).

Interactions for collaboration can be synchronous (real-time, with simultaneous participation) or asynchronous (time-independent) whilst people can be either located in the same physical place or spread in di erent places (remote). Based on where and when people interact with each other, Pidel and Ackermann [20] defined four types of collaboration – synchronous and on-site (e.g., in-person meetings), synchronous and remote (video/audio conferencing, VR), asynchronous and remote (messaging, email, shared documents) and asynchronous and on-site (e.g., laboratory work).

Research on virtual collaboration and virtual *Teams* has been growing for the past couple of decades with many articles pointing out di erent challenges that virtual *Teams* experience. For example, Naik and Kim [21] list previously identified issues relating to communication, collaboration, trust, technology, and design. In a virtual team research review by Powell et al. [22] studied issues were grouped into four general categories: input (design, culture, technical, training) relating to the resources, skills and abilities of the team, socio-emotional processes (relationship building, cohesion, trust) that a ect the e ectiveness of the team, task processes (communication, coordination, task-technology-structure fit) in order to achieve a common goal, and outputs (performance, satisfaction). Recent research on experiences of virtual work also reports that (e.g.) constant videoconferencing reduced the wellbeing of employees through increased emotional exhaustion [7], fatigue [8] or causing higher psychological demands [9] which might be related to the swift shift from traditional work settings to virtual work. Research also suggests that remote work creates challenges for employees such as work-home interference, ine ective communication, procrastination, and loneliness [11].

Adaptive Structuration Theory (AST) is a theoretical framework often used to study various aspects of virtual *Teams* and virtual work [23]. AST seeks to understand the types of structures technology enables and structures created by people interacting with these technologies. It is "a broad, process-oriented theory and is not necessarily intended for very specific explanation and prediction" [23, pp. 18-19]. Schiller and Madnviwalla [23] also explain that the wide usage of this theory might be related to still unclear constructs in terms of virtual team research. To identify potentially missing factors in the AST, an extensive body of knowledge was studied, and an updated *Extended Adaptive Structuration Theory* (EAST) framework was proposed [21]. According to the authors, EAST captures linkages "between IT, people, tasks, organizations, and processes" [21, p. 2] a ecting the success of virtual collaboration. Naik and Kim [21] describe the elements of the framework under the following categories as presented in Table 1.

However, research on virtual collaboration and virtual *Teams* often does not place emphasis on the technology or virtual environment used to accommodate that teamwork. For example, Powell et al. [22] provide an extensive definition of virtual *Teams* and their tasks whilst Naik and Kim [21] discuss technology dimension in relation to the richness of media and its fundamental characteristics. Often studies related to online work and communication describe settings that are related to 'traditional' videoconferencing tools (such as *Zoom*) or even asynchronous digital communication tools (document sharing platforms, wikis, etc.). For example, several studies examined lack of engagement, presence, and fatigue leading to reduced e ciency of online meetings (e.g., [24-25]). Thus, a concept of '*Zoom* fatigue' has appeared as explained in relation to issues with non-verbal communication, close-up eye gaze, cognitive load, self-evaluation, and lack of physical mobility (e.g., [26,24,27]). However, as early as 1996, Reynard and Benford [28] pointed out that a VR environment could provide advantages in comparison to traditional videoconferencing by providing a space for users to engage with the surrounding environment and communicate in non-verbal ways to supplement verbal communication. Additionally, research shows that current VR technology can enable deeper understanding, better sensory experiences, and enhanced sense of 'presence' [29-30].

Here, presence describes a feeling of 'being there' and should indicate that people experience VR environment just as they would experience reality. Experiences of participants and a stronger sense of presence could indicate that cognitive and emotional responses in VR are similar to real-world responses and, thus, could be comparable [31]. High presence is also associated with overall experience of the virtual environment [32] as a combination of multiple constructs including presence (immersion and engagement), flow (usability, skill, emotion) and experience consequence (judgment and technology adoption) [33].

Moreover, that sense of presence can be linked to the e ectiveness of virtual environments (e.g., [34]). Casanueva and Blake [35] divide presence into personal presence and co-presence, a feeling of 'being there' and the feeling of being in the same place with others. A study by Salnnäs [36] showed that presence and performance dif-

fered in di erent virtual environments – with text-chat media showing the lowest perceived social presence and performance and videoconference showing the highest presence.

As we believe that remote work and virtual collaboration are here to stay, we posit there is a need to understand the potential for virtual collaboration better. Especially, to understand how di erent tools can be used for more successful virtual collaborative practices. The aforementioned Extended Adaptive Structuration Theory framework is used to structure the results of this study.

2. Research approach and methodology

The paper is based on a case study of a global hospitality industry think tank. This think tank is an annual gathering of (primarily) executive-level professionals to ideate and envision the future of their industry. During the think tank, experts follow the design process from research and knowledge sharing, to inspiration, ideating and concept development. The final concepts are then demonstrated in a conference setting together with inspirational speeches from the industry. This think tank had started in 2004-2006, experienced a break but was revived during the Covid-19 pandemic. The year before this global think tank was organized using videoconferencing for collaboration. However, for the 2021 edition, they used a virtual world platform (*AltspaceVR* [37]), a broadly used videoconferencing platform (*Zoom*) and an online collaboration platform (*Batterii* [38]), to enable both synchronous and asynchronous collaboration.

The novel approach to knowledge sharing and creation by using solely virtual tools dictated the choice of exploratory approach. Two researchers took part in the think tank as passive participants, observing the events and participant interactions. The data was collected through unstructured notes of facilitated workshops during *Zoom* sessions, recordings and unstructured notes of social events, and the conference in VR to capture the process of the workshop and participant behaviour. Unstructured approach allowed researchers to collect a rich set of data and identify behaviours and situations specific to the virtual setting.

Additional data was collected through semi-structured interviews with participants including their experiences with virtual environments, and the participant experience survey to capture other aspects of experience of the VR. Observations and VR recordings were performed using *Oculus Quest* or *Meta Quest 2* headsets. The participant experience survey was developed based on a previous study by Tcha-Tokey et al. [33] with the aim at capturing user experience in virtual environments. The survey was shortened from 84 to 19 questions because, based on participants' profiles, they were not expected to complete a lengthier questionnaire. The survey included questions about familiarity with technology, attitude, engagement, immersion, skills, emotions, consequences, judgement, and technology adoption. The survey was deployed through *Qualtrics* and sent out by think tank organizers to the list of participants. By the end of March 2022, 55 responses were collected.

The notes from observations and interviews were coded using a two-tiered coding system with open codes grouped into themes. The survey was analysed to provide descriptive information and search for associations that were indicated in the previous research. However, due to the limited data set, these associations can be considered only indicative.

3. Results and discussion

The results of this research are presented by following the EAST framework [21] for categorisation: introducing structural characteristics, social interactions, and outcomes.

3.1. Organisational dimension

The global think tank was initiated by a single corporation by inviting representatives of other organisations through their network. The aim of the think tank was known to participating organisations and some participated in previous editions. However, people representing those organisations often were not familiar with the event. Also, some participants invited additional people/organisations they thought to be relevant for the event organisers. Moreover, a team running the organisation of the think tank was also newly established for this specific purpose, thus, organisational culture was not yet fully established whilst starting to work together.

The organisers o ered training sessions for the new virtual team members to familiarise with the tools and virtual environments that were used for the project. Professional facilitators were hired to help the members of the team to navigate within the systems.

3.2. Mission

The aim of the team was to imagine what the future of the hospitality industry would look like. As the task itself did not have any stated limitations - meaning that there were no criteria or stipulated stakeholder set - the complexity of the task was low. However, the process of arriving at final protypes could be considered complex as it involved multiple steps and continuously diverging and converging processes.

3.3. Task dimension

The virtual team was partially divided into two separate groups. Most team members participated in idea generation steps to a certain level of consolidation of those ideas. The final (conceptual) prototype development and visualisations were created by a selection of team members.

In total, eleven video conferencing sessions and four VR sessions for synchronous collaboration, email and an online platform for asynchronous collaboration were used for the duration of six months in 2021-2022.

3.4. Team dimension

The virtual team consisted of representatives from di erent organisations related to hospitality sector, from international hotel chains to design and architecture firms. Members of the team were also diverse in their geographical locations with most based in North America, with minorities in Europe, Asia, and Australia.

In total, there were approximately 100 participants in the team. During the process, these participants were divided into seven sub-*Teams* working on a more concrete topic. After the end of the project, a survey was sent out to which received 55 responses in total, though 10 of those were incomplete to the point of not being usable, leaving 45 viable responses.

3.5. Individual dimension

Individual level of knowledge in terms of the topic was not revealed or discussed in the process. Although team members were not very aware of each other's individual levels of knowledge, the majority of participants were in middle/upper management and/or executive

Table 2. Technological tools and their usage in the think tank

Technological tool	Purpose & way of usage
Email	Asynchronous communication with project team members. Informing about upcoming events of the project, sharing information that should be accessible later such as meeting invitations, links to virtual project spaces, experience survey. Communication was often one-directional, meaning that information went from the coordinating team towards project team members. Also, smaller sub-team members communicated via email within their teams. This tool allows written communication only and the feedback immediacy varies depending on how fast (if at all) recipients reply.
Batterii	Asynchronous communication for team members to share their insights and inspiration from various sources, organize files and documents into categories, find information easily, and provide collaborative analytics. Synchronous communication during workshops to ideate and converge ideas into structured concepts. As this tool was new to many participants, a short training was provided during the kick-o session. The tool allowed sharing several types of information, from websites to videos in a structured and visual manner. The collaborative whiteboard allowed to work on the task synchronously, meaning at the same time with the team and seeing the document being modified. However, no direct communication is available via the tool itself more than leaving written comments.
Zoom videoconferencing	Synchronous communication moments to kick-o the project and then work in groups. During these group work sessions, Batterii platform was used simultaneously as a database and a whiteboard to capture the discussions and knowledge. Zoom sessions were facilitated by a professional company, specialising in virtual collaboration. This allowed more seamless experience whilst transitioning between common meeting and work in groups during the session. Also, presentation slides were shared during the session as well as presenter's screen with Batterii environment to make sure that everyone sees the same information on screen. This tool enabled more cues to receive and transfer information as most of the team members were visible on screen, enabling partial visual/verbal communication as well. Visual setup and people's environment also transferred additional knowledge about people's experience with technology and confidence in using di erent platforms and tools and sent messages about their personalities by the way they communicated via these tools (e.g., muting/unmuting, waiting for their turn to speak or speaking up). The widespread problem with the tool was the quality of sound which varied highly depending on the hardware that was used by the team members.
AltSpace VR environment	AltSpace VR environment was used to for synchronous communication, social group interaction and knowledge sharing. Two sessions were organized for the team members to familiarize themselves with the equipment and the environment. Additionally, written instructions were sent out for registering and entering the VR environment. Even though no real people were visible, but more cues were communicated through the avatars (virtual representations) of participants – their body language, facial expressions, the looks of avatars. The quality of synchronous communication varied based on the quality of internet connection and experience of the participant. The results of the project were demonstrated in the environment and the feedback was immediate through the reactions (e.g., using emoticons to demonstrate their emotions). The VR environment tried to replicate the conference setup in the real life.
Access Platform	Multiple platforms could be used to access to the Altspace VR environment: consumer market VR sets including Valve Index, HTC Vive, and Oculus Rift, but the Meta Quest platform was presumably used by most (VR) participants as it has held >65also access the VR environment through their desktop computer, which was presumably used by a small portion of participants (easily recognisable through their lack of body motion and fixed posture). The organisers of the event sent out instructions to participants to help them set up the most commonly used VR platforms (mentioned above), and for desktop access (PC/Mac). Additionally, open Zoom sessions were scheduled beforehand in which participants could get support in their access to AltSpace VR using their preferred platform, including setting up accounts to allow for access (depending on the chosen platform). First-time users would also be recommended to 'play around' with the platform to become familiar with the handheld controls of their platform and to get past the initial disorientation which can come with the use of a VR set. Desktop users would use conventional PC game controls based on movement using a combination of the mouse and the WASD-keys on the keyboard.

level positions at their respective organisations, thus suggesting a su cient knowledge of the industry.

However, during the teamwork process, individual levels of technological knowledge were observed as well as collected through the survey at the end of the project. Team members were su ciently confident in their usage of videoconferencing platform *Zoom* and email but unfamiliar with asynchronous collaboration platform *Batterii* and virtual reality environment *AltSpaceVR*.

3.6. Technology dimension

As mentioned, di erent tools were used for di erent activities: email, *Batterii* (collaboration), *Zoom* (videoconferencing), *AltSpaceVR* (VR software), and the platform to access the VR environment (*Oculus Quest* and/or *Meta Quest 2*). The technology dimension describes how these tools (see Table 2) were used also in relation to the immediacy of feedback and multiplicity of cues.

The project coordination team decided to use di erent channels for di erent purposes – informing about the project and steps via asynchronous email communication which requires less feedback or social presence, gathering knowledge, ideating, and converging ideas both in synchronous and asynchronous ways via Batterii and *Zoom* sessions due to the nature of tasks and requirements for social presence and immediate feedback at times. Whilst socialising and sharing the outcomes via AltSpaceVR environment allowed more visual cues as well as more appropriate group social interactions compared to *Zoom* videoconferencing.

3.7. Social interaction

Social interaction (communication, collaboration, shared understanding) was observed by researchers during synchronous collaboration moments in *Zoom* and AltSpaceVR environments.

The VR environment allowed for more tacit knowledge capture in comparison to *Zoom* sessions mostly due to the body movements as well as the usage of (virtual) space, e.g., choosing to stand in di erent areas of the space which also mimicked the setting of a physical conference. Whilst waiting for the conferences to start, participants were able to socialize and communicate in groups, however, they were muted during the main event. In these moments, participants were able to communicate only via direct messaging (chat). Typing on a virtual keyboard using VR controllers took longer time than on

a physical keyboard and required more focus on the process, indicating lapsed attention to an event itself. However, non-verbal cues like gestures and head movements enabled some additional information transfer.

Group interaction and dynamics also varied with using di erent tools. In *Zoom* sessions, the quality of interactions in groups highly depended on the facilitator who asked questions or encouraged the conversation, or people who were more outspoken themselves. Turning the camera on during the *Zoom* session in most cases indicated stronger involvement in the discussion and attention to the meeting. The role of the facilitator became more prevalent to control the group dynamics and share the speaking time amongst participants. In VR sessions group dynamics felt more natural since multiple people could talk at the same time imitating the natural setting. Once in the VR environment, a participant could create their own 'sound bubble' which meant their voice can only be heard within a certain distance, and once a talking avatar moves away, their volume would drop-o much more severely than it would in the physical world.

The biggest changes in interpersonal dynamics in the VR environment related to the avatars and their appearance. Participants with diverse backgrounds (e.g., students and CEOs) experienced less social distance and more interaction possibilities. The role of social/cultural status commonly felt in real-life events was less prevalent in the virtual world. People were also able to familiarise with avatar appearances that led to participants recognising other avatars in following events and creating a social bond. The social gathering feeling in VR environment was more natural, allowing groups of avatars to communicate without interference from other attendees.

Project team members reported that the feeling of proximity of other avatars to their own avatar corresponded to real-life proximity and this led to the uncomfortable feeling at times. Also, this close distance then could lead to (unwanted) small talk, which would not happen in a *Zoom* setting and could be more easily avoided in a physical setting. Both observations and interviews suggested it may be more di cult to 'hide' or 'blend' in the VR environment in comparison to physical or even *Zoom* events.

On the other hand, in VR sessions, one could observe non-typical behaviour and surmise lack of awareness of the duality of their environments, and lack of established norms for events in VR. For example, interactions with the real-life environment such as adjusting the VR headset (which does not make sense in the postures of the avatar), changing positions between standing and seated (leading to avatars 'sinking' into the floor or floating above other avatars), or taking o the headset and putting it down (leaving the avatar in a 'hanging' marionet-like posture).

Additionally, the VR setup did not create many sound issues (which is typical in *Zoom* and other videoconferencing platforms). However, visual clarity issues occurred. For example, presenters' slides required less crowding and bigger fonts to be visible from further away. Hardware issues, bandwidth quality and lack of prior experience also a ected response times from other avatars. For example, longer pauses in conversation were needed to make sure people do not interrupt each other. Or a wave of emotes (raising hands, clapping, etc.) in reaction to the presenter appeared several seconds later.

Whilst more social interaction was possible in VR environment, it was not suitable for taking notes and doing any other activities, especially in comparison to *Zoom* videoconferencing platform. However, the setup of the overall project supported di erent activities for developing more complex set of knowledge. The ideas that were discussed in group brainstorming sessions in *Zoom*, shared on the collaboration platform Batterii and then transformed into visual representations that were demonstrated in the virtual exhibition and presented during VR events.

3.8. Outcomes: Performance

As the aim of the studied think-tank was to generate innovative ideas, inspire further innovations in the industry and collaboration between di erent stakeholders, performance quality or quantity was not in the focus. However, the organisers were satisfied with the outcome and collaboration throughout the process. The think-tank generated over 800 ideas through virtual facilitated workshops. In total, seven innovative concepts were developed and shared at a (virtual) conference on AltSpaceVR. It is important to note that the direct implementation of these concepts might not be possible any time soon or attractive to the industry now, thus, potential for implementation was also not a criterion in this exercise.

In comparison, the same think-tank generated 79 ideas and developed five concepts in 2020. However, we are not aware of the process of idea-generation, nor are we familiar with the toolset used in that edition and, thus, are not able to compare the outcomes. Nonetheless, in Ref. [22] note that previous research did not indicate significant di erences between traditional and virtual *Teams* in terms of e ectiveness of *Teams*, the quality of the outcome or number of ideas generated. However, the time taken to reach a decision has been longer within virtual *Teams*. Our interviews also revealed that due to the lack of experience or comfort with digital tools, some participants felt like they needed more time than others to adjust to virtual settings or learn how to use di erent tools.

Powell et al. [22] also provided factors potentially contributing to the success of performance, including training, goal setting, team cohesiveness, communication, and appropriate task-technology fit. In this study, di erent tools were used for di erent steps in the design process as well as instructions and training were provided to participants. Also, professional facilitators were used in each of the meeting, making meetings more structured and productive.

3.9. Satisfaction

For this study, we focused on the satisfaction with the process, especially in terms of experiences in the VR environment which was captured through interviews with participants as well as a survey with focused on the experience in the event's VR environment (AltSpaceVR). We did not focus on the experience of using other tools outside of observations or participants mentioning other tools themselves.

The experience survey demonstrated that most of the participants enjoyed (VR) events with no significant di erence between genders and/or their experience with the technology. The results are however di erent from the previous research that suggested di erences between genders or experience levels in terms of satisfaction within virtual *Teams* [22]. Nonetheless, a slight significant correlation ($r = 0.362$, $p = 0.017$) was noticed between the satisfaction with the events and the level of support received, which is in line with the study of Tan et al. [40].

From interviews and observations researchers noticed that lack of experience with the VR related to more physical discomfort and those participants were also more aware of their physical environment, with that correlation also found from survey respondents ($r = 0.352$, $p = 0.044$). This could also be observed in avatar behaviours

where avatars were looking at their hands, stretching, or otherwise lacking spatial awareness.

Familiarity with the VR environment also shone through from participants' behaviour related to social conventions like the use of emotes, with some either emoting with several seconds of delay or using (presumably) 'incorrect' emotes (e.g., raising a hand while the crowd is applauding the end of a presentation). Approximately half of all participants experienced physical discomfort during VR sessions which were related to (1) prolonged wearing of heavier headsets (e.g., Valve Index weighs 809g while vs Meta Quest 2's 503g per [41]) causing pressure points; (2) eye strains possibly due to differences in distance and strength of vision; (3) possibly di erences between experiences and expected motion. This 'VR sickness' is widely described in literature and is said to improve with more time (experience) in virtual environments [42].

Even though the respondents (n = 32) showed no significant differences in terms of satisfaction levels with di erent experience levels ($r = 0.055$, $p = 0.766$), it might also indicate that there are other aspects at play. For example, those participants who do have experience with VR may not experience much discomfort or habituation issues, but they might also have higher expectations/standards for the quality of VR environments and the organisation of events than those for whom it is still novel.

3.10. Presence

Presence in VR is often measured through indicators of objective immersion and/or subjective engagement (e.g., [43]). Our experience survey included in total five questions regarding immersion and engagement. The majority of respondents (n = 45) expressed that they had a feeling of being together with other people (75% somewhat or strongly agree) and having good conversations with others (56.8% somewhat or strongly agree). Majority of respondents also expressed sense of being at the event (63.7% somewhat or strongly agree) and were able to focus on what was happening in the VR environment (84.1% somewhat or strongly agree). Awareness of real-world surroundings such as sounds, room temperature, other people and similar aspects was neutral in a large portion of cases (29.5% neither agree nor disagree) yet did not demonstrate any relationships with other variables. This could indicate that there might have been issues with the semantics of the question as one of the reasons for slightly di erent outcome than the rest of engagement/immersion questions.

The experience survey responses also showed that there was no significant relationship between feeling of presence and the experience with technology but there was one with post-event satisfaction ($r = 0.431$, $p = 0.004$), meaning that the more 'there' respondents were, the more they were satisfied and willing to experience it again (n = 42). No relationship between presence and experience with technology goes, e.g., the opposite from De Leo et al. [44] research that demonstrated higher levels of presence from participants who had experienced VR gaming. However, in this survey we did not ask specifically about gaming experience but rather general experience with the VR.

Similarly, researchers' observations and interviews demonstrated that the VR setup had multiple benefits compared to, e.g., traditional videoconferencing tools specifically for these types of social events. First, social interactions between participants' avatars were the most described elements of participant experiences. Interviewees used descriptions such as 'more real', 'real conference', 'being at the same place', etc. However, di erences were noticed in terms of the equipment used by participants. Participants who used VR headsets to connect to the VR environment were perceived as more responsive and provided quicker feedback (e.g., in using emotes) compared to participants who used AltSpace VR via desktop PC/Mac and were more static in posture and slow in their responses.

Interestingly, interviews showed that presenters in the VR conference experienced less anxiety to present on stage when compared to the real-life setting because they were avatars talking to avatars: they felt less pressure in terms of making mistakes or forgetting something as participant reactions are less expressive. They suggested this may have to do with the lack of facial expressions of avatars, which as a technology is progressing but not close to (consumer) market-ready (e.g., [45]) On the other hand, interviewees noted that presenting to avatars felt more 'real' than presenting in a videoconferencing app, where visual support materials typically 'hide' the audience from the presenter (though when visible these allow the presenter to see the audience's facial expressions).

4. Limitations

As could be expected beforehand, participants in the event had many characteristics in common like work and industry profiles, but also were mainly joining from North America and Europe, thus limiting the representativeness of the population for other contexts. The selection of tools and applications used for this study is also not representative of the wealth of options available to the market: participants used to *Zoom* for videoconferencing may have been more comfortable collaborating than those used to MS *Teams*, Slack, or Discord, and the AltSpaceVR platform is one of a multitude of VR event platforms available including Meta Horizons, VRChat, and vSpatial (among others).

The original survey used to model the participant survey was aggressively shortened, intended to decrease the chance of non-completion, especially because we expected a relatively small sample. This puts into question whether the items used are as reliable as in their original publications without more checks and balances in place. Though the study design somewhat accounted for this through triangulation, this is not a guarantee for the reliability of the results.

This paper presents merely a single case study based on observations, and thus it is potentially a ected by researchers' biases. Furthermore, researchers' fatigue and other circumstantial factors may have inadvertently impacted the observations as the events were planned within the United States CST zone (UTC-6) during o ce hours while the researchers observed from The Netherlands (UTC+1).

5. Relevance and conclusions

This study aimed to improve the understanding of the VR technology's potential to substitute physical environment (space) for knowledge work and collaboration and identify factors that a ect user experience of remote work tools. It showed there is potential for fully remote collaboration by using a multitude of tools to reach the planned goal, one among them being VR technology. We did not observe or record any significant shortcomings that would prevent these di erent tools as an e ective alternative in the context of professional meetings/events specifically. However, that would imply the 'threshold' lies more with the lack of familiarity with and habituation to VR technology, which could be related to the (present) state of development of VR as a social/cultural paradigm.

Although VR technology enables more social interactions and seems to provide a more 'immersive' setting than videoconferenc-

ing, VR's behavioural conventions are still developing. Current users are setting the stage and shaping the culture of interactions in VR environments, and the rapid developments in the field – both in VR hardware and -software – means attained mechanical/social comfort levels could rapidly become obsolete without continuous use. VR can then become more viable if its rapid development curve will flatten to a more stable state – as it has done for other communication/collaboration paradigms like the world-wide web and email in the past [45].

With VR adoption gradually increasing, VR's social and practical conventions will also gradually develop while trying to keep pace with technological leaps. As a context for knowledge work, there are clear and distinct (practical) advantages which come with VR, but also many unknowns which make it impractical or even infeasible to see it as more than a mere alternative or complement at present. VR as a context for knowledge work has potential but alleviating the aforementioned issues will presumably only allow us to uncover more and di erent 'obstacles' to e ectively collaborate on knowledge work in a VR space. Thus, they will only bring us marginally closer to 'working in the Matrix' at this moment.

Thus, there is a further need to study how social interactions and collaboration happens (or can happen) in the VR environment and how we can identify the success factors for it in specific contexts. This would allow practitioners to determine requirements for communication and collaboration, and see which integrations are possible for them to compose a toolset meeting those requirements to improve their remote working practices.

If VR is to develop into that viable alternative environment for knowledge work and -exchange at a larger scale, we need to understand how to organise events and what is needed from organisational point of view to accommodate these activities. Paradoxically, this can only happen if more events take place and are studied to identify critical success factors for organizers, which is most likely to happen if the platform is proven to be a viable alternative or complement first.

As such, it is imperative that researchers keep exploring this developing paradigm for work, and that early adopters keep experimenting and recording their experiences to ensure we can learn as much as we can in a rapidly developing subsection of technology. Though exploration like in this study can be very useful, steps should be made to also create methods/frameworks which allow us to think more systematically and structurally about VR to e ectively develop standards which the next batch of adopters can then learn from.

A wider adoption of VR technology for remote work could eventually create bigger shifts in organisations, as it would require organisational transformations – from IT to personnel and space management, new leadership styles, etc. At a wider scale, more immersive and/or widely accepted virtual work might lead to more emphasis on further technological development, cyber security aspects, and the creation of new businesses. However, at the same time it might worsen economic inequality and even create bigger gaps in the workforce. Therefore, more research into remote/virtual knowledge work is required to understand the potential consequences of this ongoing change in how we think about work.

Abbreviations

AST	-	Adaptive Structuration Theory
EAST	-	Extended Adaptive Structuration Theory
IM	-	Instant Messaging
PC	-	Personal Computer
VR	-	Virtual Reality
WASD	-	WASD keys, a set of four keys on a keyboard used as directions to control players in video games
XR	-	Extended Realities

Acknowledgements

This paper was supported with funding from the Taskforce for Applied Research SIA (Dutch: Regieorgaan SIA) as part of the IMPULS-2020 project DIGIREAL. Authors would also like to acknowledge the supporting role of Geo Marée, who helped initiate contact with the organisation behind the think tank. Moreover, authors would thank the think tank for its open and active collaboration by providing access to events, organisers, participants, and data.

Authors' contributions

Vitalija Danivska initiated research concept and design, together with Wouter van Tankeren collected and analysed observation and interview data, Wouter van Tankeren analysed survey data. Both authors interpreted data and prepared the manuscript. Vitalija Danivska wrote the theoretical overview whilst both authors prepared other parts of the manuscript. Wouter van Tankeren reviewed the initial draft of the manuscript. Both authors reviewed and approved the final manuscript.

Conflicts of interest

All authors declare that they have no conflicts of interest.

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