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Investigating the Potential of Virtual Reality Medium for Collaborative Work: Results from a Series of Pilot Studies

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Abstract

This project provides a preliminary examination of the potential fit between virtual reality environments for different components of group collaboration. We explore user-perceived characteristics of VR solutions, such as ease of use, intuitiveness, and ease of access to features intended to provide productivity gains for groups and individuals, and the potential association with overall satisfaction and intention to use. This paper presents insights from pilot testing the use of VR in undergraduate and graduate courses for potential fit, as well as a group of industry practitioners to further examine the role of maturity level. We also explore the applicability of the theory of Task-Technology Fit to assess the benefits that the VR medium may offer for group collaboration, co-learning, and peer learning. While the findings of our pilot study show that the VR technology's potential benefits for collaborative work are not currently palpable to students in a typical course setting, they do offer some concrete clues for improvement and starting points for future studies.

Keywords: virtual reality, computer-mediated collaboration, technology acceptance model.

1. INTRODUCTION

Virtual reality (VR) is used in the fields of medicine, biology, engineering, and science to enable experiences that are infeasible, costly, or unsafe otherwise (e.g., Alaraj et al., 2011). Students can take field trips to the inner parts of human anatomy, deep waters, and even space (Çalişkan, 2011). Medical students can perform medical procedures in VR that prepare them for real-world settings (Alaraj et al., 2011). Students can attend lectures and engage in group activities in the VR environment (Han et al., 2022). Although the potential fit (Goodhue & Thompson

1995) between VR technology and different components of group work has not been extensively studied in the IS literature, the field provides a large body of work on computer-mediated collaborative work.

Researchers have studied how different aspects of technology design and group composition (e.g., user interface) affect different dimensions of computer-mediated collaborative processes (ideation vs. synthesizing) (Dennis 1996; Pinsonnault et al. 1999; Robert et al. 2008). These previous studies can help identify and study antecedents of potential fit between VR technology and the group processes that can benefit.

Previous research has examined the impact of immersive VR environments on learning outcomes in the aforementioned areas with inconclusive results (Hamilton et al., 2021; Yoshimura & Borst, 2021). The technology learning curve, difficulties of getting accustomed to wearing VR headsets, and incompatibility of VR headsets with other forms of vision accessories (lenses, eyeglasses) are among the factors that may play a role in determining the extent to which the immersive environment will be adopted more widely in educational settings. Related to the learning curve, Han and colleagues (2022) used prior VR experience as a control variable in their longitudinal study of VR use (with general or customized avatars) and discovered that it had an impact on constructs such as group cohesion and presence.

In this pilot study, we focused on the use of VR in the classroom and bridge to a small focus group of industry practitioners to further shed light on the role of VR technology maturity level on potential fit between collaborative tasks and VR technology (Gebauer & Ginsburg 2009). We review the processes of group work and examine user-perceived characteristics of VR hardware and software, such as ease of use, intuitiveness, and ease of access to features, productivity gains for groups and individuals, and the potential association that those metrics have with the intention to use. The broader quest is to better understand the potential fit of VR environments for managing attentional resources (capacity) (Hirst & Kalmar 1987) and enabling group collaboration, co-learning, and peer learning. The study presented in the current paper is intended as a first step to help guide future investigations and the collection of additional data. More specifically, we ask the question to what extent VR technology at its current maturity stage is a fit for collaborative work in a typical educational setting.

2. LITERATURE REVIEW

Group processes and outcomes have long been studied in the computer-mediated collaboration literature (e.g., Dennis & Valacich, 1999; De Vreede et al., 2003). Many cognitive and social interventions (e.g., social comparison, the anonymity of contributions) have been implemented with the help of technology (e.g., through peer performance charts) to improve computer-mediated group performance (Carte et al., 2006). To assess the potential uses and benefits of immersive VR environments for group tasks, research is needed to develop a deeper understanding of how the VR medium compares to other media in enabling or hindering group collaboration. Our literature review focuses on representative studies of VR use in group work and computer-mediated group work.

Virtual Reality in Learning Groups

Hamilton et al. (2021) provide a comprehensive review of VR use in teaching and learning environments when they examine twenty-nine studies, most of which focus on cognitive and procedural tasks. Purely cognitive tasks use VR to immerse students in experiential learning environments, such as exploring marine life during class time (Çalişkan, 2011). Procedural tasks involve skill-based operations, such as dental or medical procedures (Alaraj et al., 2011). In contrast, the collaboration work involved in the current study is cognitive and social.

Our investigation of the potential impacts of VR use was initiated on the premise of Herbert Simon's notion of attention scarcity (Simon, 1947), meaning that the allocation of attention as a scarce resource in educational settings is essential. We further build on King's (1999) work on cognitive psychology underpinnings of peer learning that highlights the necessity of structuring, guiding, and observing peer interactions, which may be enabled at higher levels in the VR environment compared to a regular video conferencing environment. And last, we apply the broader concept of Task-Technology Fit to the VR environment and its equipment. Our quest is to identify areas and tasks for which a VR environment may offer advantages for group collaboration and group work.

Evidence about the impacts of VR environments on learning outcomes compared to non-immersive counterparts is currently inconclusive.

ISSN: 2473-4901
v10 n6136

Less than half of the studies (12 of 29) reviewed by Hamilton et al. (2021) reported a positive impact on learning outcomes. Similar results have been reported for the use of VR for procedural tasks where about a third of the studies reviewed by Hamilton et al. (2021) have shown a positive impact. Nevertheless, procedural skills like those needed to conduct surgery require practice, and VR is, at least conceptually, a well-suited medium to enable the practice phase.

In their investigation of students' perceptions of lectures and presentations in VR compared to a desktop environment, Yoshimura and Borst (2021) used self-reported cognitive constructs, such as SUS (developed by Slater, Usoh, and Steed, 1994) to assess the presence, co-presence, attentional allocation, and perceived message understanding. Their study showed that headset presenting benefited from increased attentional allocation over both headset viewing and desktop viewing. Also, for headset presentation, there might be a trend towards higher perceived emotional and behavioral interdependence over desktop viewing. Han and colleagues (2022) examined experiential measures such as enjoyment and spatial presence for customized vs. general avatars used in the VR environment, which is similar to the construct of cohesion in the computer-mediated group work literature (Salisbury et al., 2006). Han et al. (2022)'s groups were collaborating over an 8-week long period, and they reported a positive trend across all measures, attributing part of it to familiarity with the technology.

We note that the lack of familiarity with VR equipment and environments is a key factor in current studies of the VR medium. VR equipment and use are not as widespread as web-based and mobile applications. Therefore, the learning curve and level of familiarity with the tool must be considered when VR group work is studied (Allcoat & von Mühlenen, 2018). What we seek in the current study is higher levels of learning and meaning-making (Bloom et al., 1956; King, 1999) that would occur as part of group collaboration. Therefore, the affordance of VR in managing attention and group processes and familiarity with technology are all critical components.

Computer-Mediated Group Work

Process gains and losses have been examined in the IS literature for tasks related to group idea generation and discussion (De Vreede et al., 2003; Pinsonneault et al., 1999). Losses during electronic group work are commonly attributed to attentional processes, lack of attention to others' ideas, and attention diversion caused by excessive exposure to others' ideas. In the area of group collaboration and an expansive move to work from home, attentional diversion because of environmental factors such as those experienced in a typical home office (e.g., family members, pets) still needs to be studied more thoroughly. Research is also needed to unravel the impacts of VR as a new medium for group collaboration. Like in the electronic brainstorming literature, VR studies must examine whether the process gains outweigh potential process losses when group collaboration occurs in the VR environment. For instance, would the additional environmental and avatar-based cues provided in the VR improve cognitive stimulation? Or would those additional cues and environmental elements cause cognitive interference? And would process losses outweigh process gains as suggested in the electronic brainstorming literature (Pinsonneault et al., 1999)? Is group cohesion easier to establish than in non-virtual environments (Salisbury et al., 2006)?

Collaborative group work also requires media characteristics that would foster both convergent and divergent phases of the group process (Zhou & Shalley, 2007). Generation of diverse ideas, filtering through those ideas, and synthesizing the most valuable ideas are activities that are present in most forms of collaborative work (Dennis 1996; Dennis et al., 1996; De Vreede, et al., 2003). While the VR medium may offer advantages in the areas of gaming, biology, and medicine, the same fit may not exist for collaborative work with its specific requirements, such as those for facilitation and its saliency, group structuring, and mechanisms for evaluating shared ideas (Briggs 1995; Fjermestad & Hiltz 2001; Santanen et al., 2004; Valacich et al., 1994). Therefore, it is important to examine the research question by considering the specific requirements of the collaborative work through the lens of task-technology fit.

Technology Acceptance Model, Value-based Adoption Model, and Task-Technology Fit

The Technology Acceptance Model (TAM) and its derivatives such as the Value-Based Adoption Model (VAM) aim to explain adoption or intention to use. The theory of task-technology fit (TTF) posits that a potential fit or lack thereof can predict performance gains or utilization of a given technology (Goodhue & Thompson, 1995). TAM, TTF, and VAM have been applied to study different technologies and systems such as mobile applications, electronic health record systems, and IoT smart home services (El-Gayar et al., 2010; Gebauer & Shaw, 2004; Kim et al.

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2007). Collaborative work requires support for ideation, discussion, synthesizing, and/or potentially collaborative documentation of those steps. Characteristics of VR hardware and systems are constantly changing. At the time of the study (2022), Meta's Oculus 2 Pro was one of the latest devices on the market with Oculus 3 being expected to arrive within a year. The desktop app, and the phone app for pairing required frequent updates, more importantly, the handles pair/umpiring imposed complexity requiring extra setup time. In summary, the pairing and use were not seamless in an educational setting where each student had to borrow and set up the device for use. The conditions may differ once VR headsets become a household item like cell phones or when all students can be provided with dedicated devices over the course of the semester. Therefore, the TTF literature focusing on maturing is particularly relevant for this area of study (Gebauer & Ginsburg, 2009). Gebauer and colleagues (2007) differentiate between expected usefulness and actual usefulness, and the impact that technology maturity has on actual usefulness directly and indirectly through extent of use. Technology maturity, while not studied in this project, has appeared as a common theme in the participants' responses to the open-ended questions.

3. METHODOLOGY, TASKS, AND PROCEDURES

For an exploratory examination of potential fit, like the research studies reviewed by Hamilton and colleagues (2021), we selected group work in undergraduate and graduate courses. Because VR equipment and application setup were shared as an obstacle to performance, to identify whether these challenges are universal or arise only because of the specific context of the classroom, we asked a group of industry partners to test the equipment and environment in their workplace. We believe that the insights shared by class-level quantitative analysis along with qualitative responses as well as the reflections provided by industry partners in the focus group will allow us to design future examinations of this phenomenon better when the technology matures, and the devices and applications are easier to use for novice users. The first pilot study involved undergraduate students who performed a task in relation to the course group project that required idea generation, sharing, and synthesis. The graduate students engaged in similar collaborative tasks in the context of their course. The last study was conducted in an industry setting, in which geographically dispersed team members used VR for enhancing group meetings.

Pilot Study in the Undergraduate Course

The first pilot study was completed in a 200-level information systems course (Fall of 2022). Students were asked to conduct part of their group meetings (2 of 4) in a VR environment (Horizon Workrooms). To prepare for the VR-enabled group meetings, students needed to create a Meta account, pair VR headsets with phones, and install Horizon Workrooms Desktop as well as Meta Quest Remote Desktop. The study used Meta Quest 2, but Quest 3 is now the standard at the time of this revision.

The group work as such involved brainstorming, working on shared group documents, estimating numbers (in the context of group projects), creating charts, and calculations. Following the assignment, students were asked to respond to questions related to ease of use (EOU) and performance (PERF), as well as overall satisfaction with the experience and their intentions to use the VR environment for group work in the future (Table 1). The items were taken from the Task-Technology Fit study by El Gayar and colleagues (2010). Thirty-four students participated in the survey, which used a 1-5 Likert scale. The research model is shown in Figure 1 below. For the preliminary study, we focused on the direct links between the two independent (EOU, PERF) and dependent variables (Intention to use, Overall satisfaction) each (Davis, 1989). A screenshot of a typical meeting in Workrooms is shown in Appendix A, measurement items are listed in Appendix B.

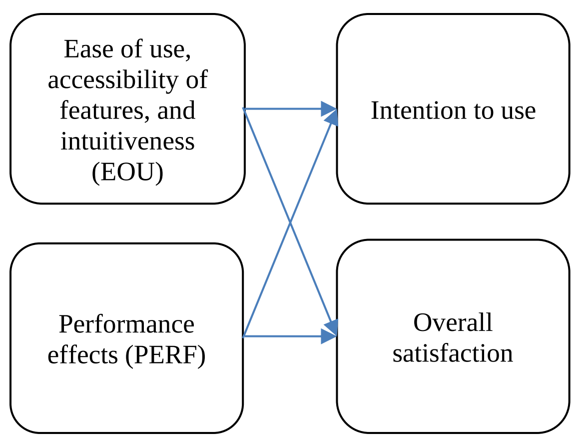

Figure 1 Research Model (TAM, Davis 1989)

Student answers appear to reflect the considerable effort required to set up the device and environment. All scores are relatively low (Appendix B). As dependent variables, the overall satisfaction with the VR environment was examined through the question: *Please assess*

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v10 n6136

how satisfactory in meeting your needs you find the VR meeting environment, while the intention to use was assessed through the question: *If I'm given the choice, I will use the VR meeting environment for conducting group meetings*. Lavaan in R was used for factor analysis and regression analysis. The results of our analysis indicate that overall satisfaction (or lack thereof) was associated with ease of use but not performance measures. Conversely, intention to use was associated with performance and not ease of use (Table 1).

The preliminary findings show that while ease of use appears to impact how satisfying the group experience has been in the VR environment, intention to use the medium may be based more upon the potential impacts on performance and less on ease of use. Lack of familiarity with the technology might play a role. As Han and colleagues (2021) have shown, the ease-of-use measures may improve as participants spend more time in the VR environment and get accustomed to the hardware and setup.

	EOU	PERF
Overall satisfaction	0.908 (p: 0.05)	1.027 (p: 0.08)
Intention to use	0.918 (p: 0.266)	2.986 (p: 0.004)
Fit measures: RMESA 0.07 – SRMR 0.059 CFI: 0.992 – TLI: 0.989		

Table 1: Overall Satisfaction and Intention to Use

Students were also asked to share their perspectives by answering two open-ended questions: (1) *If you were to compare the capabilities of Zoom and the VR meeting environment, how would you assess the challenges and capabilities of the VR environment for conducting group meetings or for collaboration?* (2) *Would you anticipate that future advances in VR hardware and environmental features may impact VR meeting environments used by you for group meetings and collaboration?* Our analysis of participants' responses identified themes related to (1) setup, (2) cost of ownership, and (3) interactivity. For instance, participants have shared the following: "*VR seems harder to set up in general compared to Zoom which usually only takes a few seconds.*" "*Yes. If VR headsets become more accessible and widespread, this could be a great way to have meetings.*" "*…If everyone had a VR headset, the VR environment would be a great alternative to Zoom which allows for a more interactive meeting with tons of features…*"

Deeper analyses of the written responses are needed to identify additional themes and relate them to the concepts assessed via the structured survey.

Pilot Study in a Graduate Course and Focus Group in the Industry Setting

Individual factors, as well as the meeting context and purposes, were different for the graduate student research discussions and for the workplace meetings. The sample sizes for the graduate course (N=4) and industry settings (N=4) were small, preventing us from building a structural model on the data (Spring 2023). However, we present a summary of the ideas shared in those two settings. The work with graduate students and industry partners involved activities over a longer period of time that could potentially alleviate the adverse impact of the technology learning curve; however, the anticipated alleviating effect was not observed in either group.

Figure 2 contrasts satisfaction and intention to use provided by the undergraduate participants, graduate participants, and industry partners. Part of the differences may result from different perceptions about the relevance of return on investment. While the undergraduate and graduate participants most likely assumed that the decisions about using the VR hardware and environment had already been made by their instructor or department, the industry partners were in fact weighing the costs and benefits of adoption and wider use from a decision-making perspective that was focused on return on investment and acceptances by stakeholders.

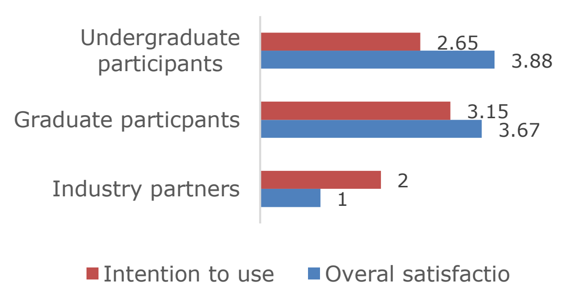

Figure 2 Overall Satisfaction and Intention to Use for the Three Groups

Similar to the undergraduate participant group, graduate student participants shared concerns over set-up time and complexity (long update times). Notable challenges included the inability to show or see facial expressions, the weight of the headset and the headache it causes, and the intricacies of using a computer device and the keyboard while in a work meeting. A general

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theme among the graduate students was that using VR technology at this phase of its development for work or educational purposes was counterproductive. Students asserted that the affordances of the VR environment could enhance their gaming experience or could be helpful for training in areas in which adding a third dimension or having action choices such as rotation was essential for the understanding of the subject matter (e.g., architecture or construction design). However, such a need does not exist in a regular peer collaboration meeting where the subject matter does not benefit from VR-specific features or operations.

The sentiments shared by the industry partners were more strongly against VR for two specific reasons: first the R&D nature of freely available meeting applications (used here Horizon Workrooms) and second the cost of the VR headsets. An excerpt is shared here: *"…VR environment has yet to come into a place of necessity, much of it is still in a beta phase and has yet to be designed for wider use cases. Furthermore, at its current price point, it can be argued that this is seen as more of a luxury and many businesses/corporations likely wouldn't lean into the expense of adoption unless there was a clear return on investment….*" Like the two groups of student participants, the industry partners also pointed out the limitations of the hardware that raised ergonomic concerns and lacked adaptive solutions for audiences with sensory impairment. In addition, the industry partners criticized the setup, download, and updating time for the Oculus software and the apps thereon. Another strong sentiment expressed about the bugs is included here: *"…There are countless bugs with running applications and pulling over integrated information from existing Meta/Fb/IG profiles (Avatar re-creation being one of the main discoveries). While there are promising ideas on the 'horizon' for what this may achieve in future iterations, the creative vision needs instead to rectify its current user adoption problems which are outlined (ad nauseam) in the app store reviews…*". It is noteworthy that the industry partners who participated in this study's focus group were involved in research and development in the areas of technology and UI/UX design at a Fortune 500 company. The reaction points to a need for a technological journey that is not yet ready for typical collaborative group work.

4. CONCLUSIONS AND FUTURE DIRECTIONS

The current study provides a preliminary perspective into the potential fit of VR technology for group collaboration in a general topics course, as opposed to specialized courses such as in marine biology or medical surgery practice where VR provides clear advantages. While the questionnaire fails to decouple different subprocesses of group collaboration in educational settings, it sheds light on how technology setup and environment pose challenges to novice users (those who have no or little prior experience with VR technology). While the use cases of VR for group work are not new, investigating process gains and process losses warrants further research.

Currently, the considerable effort required during setup and perceived lack of ease of use appear to limit user satisfaction and may also have an impact on the intention to use. These findings are consistent with the TTF literature that takes into account technology maturity (Gebauer et al., 2007). We conclude that future research models should include constructs that account for maturity, the extent of use, and the impact thereof on the actual usefulness of VR technology. The open-ended responses from participants clearly signal a mismatch between perceived usefulness and actual usefulness. It is thus imperative that the research model distinguishes between the two.

The broader goal of this stream of work is to examine the potential of the VR environment for enabling and advancing peer learning in geographically dispersed groups. Taking an attention-based view of peer learning (Simon 1947), for group ideas to be processed and for meaning-making to occur, managing the attentional resources of group members is essential. If the VR environment is to become a medium through which individuals co-exist, share, discuss, and access group-related intellectual resources, how should this medium be different from current alternatives (e.g., video conferencing and other collaborative development environments)? Which elements of the VR environment's structure and design enhance or impede peer learning? New environmental design models that resemble those pertinent to traditional user interfaces must be developed to ensure that individuals' attentional resources are directed and harnessed to augment process efficiency and outcome quality. As was pointed out during the review process, it is noteworthy to share that this was not done in a VR lab and we had no administrative support for the headsets. The experiment did not use any multiple mobile device management (MDM) application either. The VR lab would simplify the setup and administrative support would remove several obstacles and challenges for the classroom setting. Future experiments will benefit from such settings, although moving to multiple mobile device management (MDM) applications could enhance adoption at the classroom level.

5. REFERENCES

Allcoat, D., & von Mühlenen, A. (2018). Learning in virtual reality: Effects on performance, emotion and engagement. *Research in Learning Technology*, 26, 2140. https://doi.org/10.25304/rlt.v26.2140.

Alaraj, A., Lemole, M., Finkle, J., Yudkowsky, R., Wallace, A., Luciano, C., … Charbel, F. (2011). Virtual reality training in neurosurgery: Review of current status and future applications. *Surgical Neurology International*, 2, 52. https://doi.org/10.1080/0144929X.2016.12 12931.

Alhalabi, W. S. (2016). Virtual reality systems enhance students' achievements in engineering education. *Behaviour & Information Technology*, 35, 919–925. https://doi.org/10.1080/0144929X.2016.12 12931.

Çalişkan, O. (2011). Virtual field trips in education of earth and environmental sciences. *Procedia-Social and Behavioral Sciences*, 15, 3239–3243. https://doi.org/10.1016/j.sbspro.2011.04.27 8.

Carte, T., Chidambaram, L., Garfield, M., Hicks, L., Cole, C. (2006). Group Creativity and Collaborative Technologies: Understanding the Role of Visual Anonymity. In: Dimitriadis, Y.A., Zigurs, I., Gómez-Sánchez, E. (eds) *Groupware: Design, Implementation, and Use. CRIWG 2006. Lecture Notes in Computer Science*, vol 4154. Springer, Berlin, Heidelberg. https://doi.org/10.1007/11853862_2.

Davis, F. D. (1989). Technology acceptance model: TAM. *Al-Suqri, MN, Al-Aufi, AS: Information Seeking Behavior and Technology Adoption*, *205*, 219. https://doi.org/10.2307/249563.

Dennis, A. R. (1996). Information exchange and use in group decision making: You can lead a group to information, but you can't make it think. *MIS Quarterly*, 20(4): 433-457. https://doi.org/10.2307/249563.

Dennis, A. R., & Valacich, J. S. (1999). Research note, Electronic brainstorming: Illusions and patterns of productivity. *Information Systems Research*, 10(4): 375-377. https://doi.org/10.1287/isre.10.4.375.

Dennis, A. R., Valacich, J. S., Connolly, T. & Wynne, B. E. (1996), Process structuring in electronic brainstorming, *Information Systems Research*, 7(2): 268-277. https://doi.org/10.1287/isre.7.2.268.

De Vreede, G. J., Davison, R. M., & Briggs, R. O. (2003). How a silver bullet may lose its shine. *Communications of the ACM*, 46(8): 96-101. https://doi.org/10.1145/859670.859676.

El-Gayar, O. F., Deokar, A. V., & Wills, M. J. (2010). Evaluating task-technology fit and user performance for an electronic health record system. *International Journal of Healthcare Technology and Management*, 11(1-2), 50-65. https://doi.org/10.1504/IJHTM.2010.033274

Fjermestad, J., & S.R. Hiltz (2001). A Descriptive Evaluation of Group Support Systems Case and Field Studies, *Journal of Management Information Systems*, 17(3): 115-159. https://doi.org/10.1080/07421222.2000.11 045657.

Gebauer, J., & Ginsburg, M. (2009). Exploring the black box of task-technology fit. *Communications of the ACM*, 52(1), 130-135. https://doi.org/10.1145/1435417.1435447.

Gebauer, J. & Shaw, M. J. (2004), Success Factors and Impacts of Mobile Business Applications: Results from a Mobile e-Procurement Study, *International Journal of Electronic Commerce*, 8 (3), 19-41. https://doi.org/10.1080/10864415.2004.11 044304.

Gebauer, J., Shaw, M. J., and R. Subramanyam (2007). *Once Built Well, They Might Come: An Empirical Study of Mobile E-Mail, Working Paper* (October 7, 2007). Available at SSRN: https://ssrn.com/abstract=1282110 or http://dx.doi.org/10.2139/ssrn.1282110

Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS quarterly*, 213-236. https://doi.org/10.2307/249689.

Hamilton, D., McKechnie, J., Edgerton, E. et al. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computer Education*, 8, 1–32.

ISSN: 2473-4901
v10 n6136

https://doi.org/10.1007/s40692-020-00169-2.

Han, E., Miller, M., Ram, N., Nowak, K. & and Bailenson, J. N., Understanding Group Behavior in Virtual Reality: A Large-Scale, Longitudinal Study in the Metaverse (May 14, 2022). *72nd Annual International Communication Association Conference*, Paris, France., Available at SSRN: https://ssrn.com/abstract=4110154

Hirst, W., & Kalmar, D. (1987). Characterizing attentional resources. *Journal of Experimental Psychology: General*, *116*(1), 68. https://doi.org/10.1037/0096-3445.116.1.68.

Kim, H. W., Chan, H. C., & Gupta, S. (2007). Value-based adoption of mobile internet: an empirical investigation. *Decision support systems*, *43*(1), 111-126. https://doi.org/10.1016/j.dss.2005.05.009.

Pinsonneault, A., Barki, H., Gallupe, R. B., & Hoppen, N. (1999). Electronic brainstorming: The illusion of productivity. *Information Systems Research*, 10(2): 110-133. https://doi.org/10.1287/isre.10.2.110.

Robert, L. P., Dennis, A. R., & Ahuja, M. K. (2008). Social capital and knowledge integration in digitally enabled teams. *Information Systems Research*, 19(3): 314-334. https://doi.org/10.1287/isre.1080.0177.

Salisbury, W.D., Carte, T., & Chidambaram, L. (2006). Cohesion in virtual teams: validating the perceived cohesion scale in a distributed setting. *Data Base*, 37, 147-155. https://doi.org/10.1145/1161345.1161362.

Santanen, E. L., Briggs, R. O., & De Vreede, G. J. (2004). Causal relationships in creative problem solving: Comparing facilitation interventions for ideation, *Journal of Management Information Systems*, 20(4): 167-197. https://doi.org/10.1080/07421222.2004.11045783.

Simon, H. A. (1947). *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. Macmillan Co, New York, NY.

Slater, M., Usoh, M., and Steed, A. (1994). Depth of presence in virtual environments. *Presence* 3, 130–144. https://doi.org/10.1162/pres.1994.3.2.130.

Valacich JS, Dennis AR, Connolly T. (1994). Idea Generation in Computer-Based Groups – A new ending to an old story. *Organizational Behavior and Human Decision Processes*, 57(3): 448-467. https://doi.org/10.1006/obhd.1994.1024.

Yoshimura A and Borst CW (2021) A Study of Class Meetings in VR: Student Experiences of Attending Lectures and of Giving a Project Presentation. Front. *Virtual Reality*, 2:648619. https://doi.org/10.3389/frvir.2021.648619.

Zhou, J, & C. Shalley (2007). *Handbook of Organizational Creativity*, Lawrence Erlbaum Associates Inc, US

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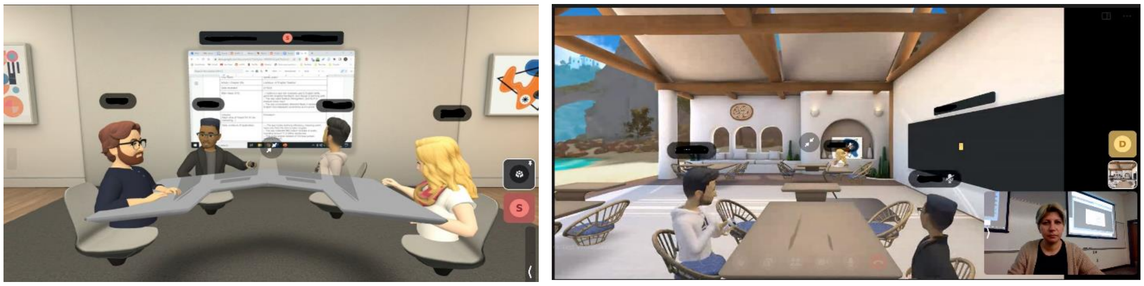
Appendix A

Left: All Members in VR Environment; Right: Some Members on Desktop



Appendix B

Measurement items and factor loadings (undergraduate pilot study)

Latent variable	Measurement Items (N=34)	Mean (1-5)	Standard Deviation	Factor loadings
Ease of use, access, and intuitiveness Performance	It is easy to use the VR meeting environment functionalities that I need.	2.79	1.02	0.657
	I find it easy to get the VR meeting environment to do what I want it to do.	2.76	0.94	0.757
	My interaction with the VR meeting environment is clear and understandable.	2.91	0.98	0.764
	I can get to the VR meeting environment quickly and easily when I need to.	2.79	1.17	0.997
	It is easy to access the VR meeting environment that I need to be in.	2.76	1.06	0.962
	The features of the VR meeting environment are displayed in an intuitive/understandable form.	3.06	1.03	0.909
Performance	Using the VR meeting environment may improve the quality of the group meetings.	3.03	1.07	0.721
	Using the VR meeting environment may enable me to accomplish meeting plans more quickly.	2.61	1.14	0.880
	Using the VR meeting environment may increase the effectiveness of group meetings.	2.79	1.17	0.953
	VR meeting environments may be an important and valuable aid to me in performing my responsibilities during group meetings.	2.73	1.15	0.986
	Using the VR meeting environment may increase my productivity in group meetings.	2.70	1.21	0.970