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Effects of Virtual Reality on Students' Creative Thinking during a Brainstorming Session

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Abstract: Brainstorming is a well-known technique for fostering student creativity. Due to the COVID-19 pandemic, brainstorming sessions were recently held online, using web-based tools and video calls. Virtual Reality (VR) can also be an alternative for brainstorming sessions. However, there is currently limited research on brainstorming sessions using VR, and its impact on students' creative thinking is still unknown. We conducted a preliminary study that compares brainstorming in VR and brainstorming with a web-based online whiteboard to study how each communication method affects students' creative thinking. Given that students had the same amount of time for both VR and web sessions, the results reveal that there is no significant difference in the quality or quantity of ideas. Even though participants said VR was difficult to use, the results of VR and web sessions were similar. We believe that if the students become familiar with VR, they will be able to develop more ideas in the virtual space.

Keywords: Brainstorming, online learning, virtual reality, online whiteboard, collaborative learning

1. Introduction

During the COVID-19 pandemic, online activities became common education methods. There are various ways to deliver lessons to the students online including live video streaming, asynchronous video broadcasting, or synchronous online classes. In classes that are interactive and collaborative, the communication medium plays a fairly big role (e.g., design classes; policy studies classes; project-based learning classes). Brainstorming is a standard activity that is often used to foster student creativity in face-to-face classes. When the brainstorming is conducted online, online whiteboard tools are generally used, e.g., Google's Jamboard, Miro board, etc. These tools allow the students to share a whiteboard online with their peers and brainstorm together on ideas. Regularly used functions of the online whiteboard for brainstorming are typing messages, drawing, putting on sticky notes, rearranging the notes and messages. Online whiteboards enable online brainstorming and meeting and are usually used together with video call applications, while some of the online whiteboards have the video call function included as a part of their system. Besides web-based whiteboards, Virtual Reality (VR) could be an alternative workspace for distant creative sessions. In the last few years, VR has exploded in popularity as the headsets have been available for general users. A VR headset is a head-mounted device that immerses the user in virtual reality. Using VR, it is possible for students to also interact and have a brainstorming session online.

There exist various studies on VR's effect on creativity (Lin, Wang, Kuo, & Luo, 2017), however, studies focusing on comparing VR brainstorming sessions and brainstorming sessions using an online whiteboard has not been conducted. In this paper, we study the difference between online whiteboard brainstorming sessions and VR sessions in terms of quantity of ideas, quality of ideas, cognitive load, and satisfaction.

2. Background

2.1 Brainstorming

Brainstorming is known as an individual or group method for creating ideas, increasing creativity, and finding solutions (Wilson, 2013). Based on Osborn (1953), there are four rules for brainstorming. First and foremost, no evaluation should take place during the session, no matter how absurd the ideas may appear. Second, the team should generate as many ideas as possible. Third, wild and crazy ideas are welcome. And the last, creating new ideas on top of each other's ideas is important. One of the well-known brainstorming practices is to write ideas on sticky notes and collaboratively discuss and group them (Kumar, 2012).

2.2 VR and Creativity

Thornhill-Miller and Dupont (2016) studied if VR enhances creativity and innovation, under-recognized potential among converging technologies. They reported that VR provides a cost-effective means of implementing and optimizing nearly all conventional creativity enhancement techniques, while also providing powerful new possibilities that are not available through traditional means. In 2017, Lin, Wang, Kuo, and Luo (2017) studied the effect of virtual reality 3D exploratory education. Their result showed that students' creativity and leadership in exploratory education produced the highest creativity with VR.

3. Methods

3.1 Experiment Design

We conducted a repeated measures study considering the system used for brainstorming as the independent variable. The dependent variables are the quality and quantities of the generated ideas, the perceived ease of use of the system as well as its perceived usefulness. The study participants were three graduate students at a university in Japan. All students were enrolled in the same program in the graduate school of informatics and had experienced brainstorming one to five times before the experiment.

The study was conducted over two phases as shown in Fig. 1. As a first step, we introduced the rules of brainstorming and conducted a brainstorming session with the participants using paper and pen to reduce the ordering effect. During the first phase, we first asked the participants to use the virtual reality headset for twenty minutes to become familiar with it. After that, participants were asked to use the VR headset and provide ideas to the problem used by Hender et al.(2002): "A restaurant located next to campus is losing customers. What can the restaurant do to retain its customers?" The participants used the Spatial application on the Oculus Quest 2 headset for the brainstorming session conducted using VR. Spatial allows participants to meet in a meeting room, scribble on a whiteboard and post sticky notes on the board as shown in figure 2. Phase 2 consisted of a web-based brainstorming session using Zoom for the meeting and Google Jamboard for the ideation session. For the web-based brainstorming session, the participants were assigned a modified version of Hender et al.(2002) problem: "The university library campus is visited less. What can the library do to attract more students?"

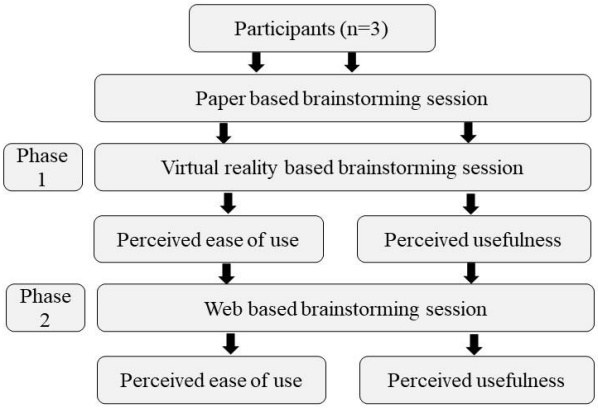

Figure 1. Experimental Procedure.

Both the VR and web-based brainstorming sessions were structured similarly. First, the facilitator presented the problem and asked the participants to generate ideas and write them on sticky notes for a period of ten minutes. Once completed, the participants were asked to share their ideas and explain them. The participants were then given five minutes to generate additional ideas and share them. After that, the participants were asked to group similar ideas together, name the groups, and choose their final solution by discussion.

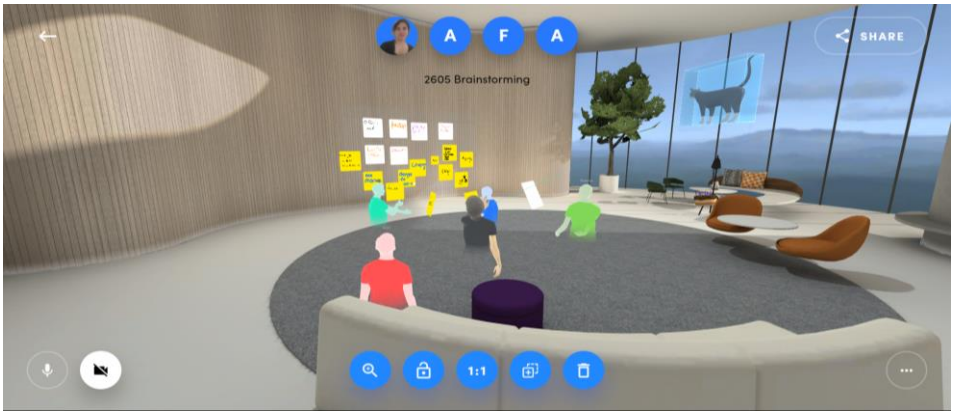

Figure 2. Overview of the Brainstorming Session using VR.

3.2 Dependent Variables

We defined four dependent variables for this experiment as follows:

- *Quantity of ideas:* The quantity of ideas was determined by counting the number of ideas generated by each participant and summed.
- *Creativity of ideas:* The creativity of the idea was measured in terms of the originality of the idea. Two raters coded all ideas for originality. A 5-point scale was used (1 as not original, 5 as highly feasible). Examples of a highly original and a highly unoriginal idea, respectively, are: “Create a book swapping campaign in the library” and "install comfortable chairs in the library" and “Teach courses in smaller groups.” The rater’s agreement was measured by considering that the raters are in agreement if the ratings do not have more than one point of difference (Diehl & Stroebe, 1987). An inter-rater Agreement was present in 96.4% of the cases. As the inter-rater agreement is high, we used the scores of the first rater for our analysis. We calculated the mean originality for the ideas generated using VR and the ideas generated using the web.
- *Ease of use:* Perceived ease of use was measured to assess the cognitive load of each system. Perceived ease of use was measured using the instrument developed by Sambamurthy & Chin(1994). The ease of use was measured using 5-point Likert-scale questions where 1= strongly disagree and 5=strongly agree. The responses for the questions were summed to calculate the perceived ease of use (Hender et al., 2002).

- *Usefulness:* Perceived usefulness was measured to assess the usefulness of each system to conduct brainstorming sessions. Perceived usefulness was measured using the and adaptation of the instrument developed by Sambamurthy & Chin(1994). The usefulness was measured using 5-point Likert-scale questions where 1= strongly disagree and 5=strongly agree. The responses for the questions were summed to calculate the perceived usefulness.

4. Results

A t-test was used to analyze the differences in the number of ideas, the creativity of ideas, perceived ease of use, and perceived usefulness between a VR-based brainstorming session and a web-based brainstorming session.

As displayed in Table 1, there was no significant difference in the number of ideas generated using VR compared to the use of the web application. There was also no significant difference in the quality of ideas generated using VR compared to the use of the web application.

The ease of use of web-based brainstorming sessions is significantly greater than the ease of use of VR-based brainstorming sessions.

The usefulness of web-based brainstorming sessions is significantly greater than the usefulness of VR-based brainstorming sessions.

Table 1. *Quantity and quality of ideas, ease of use, and usefulness of brainstorming using VR and web*

	Virtual Reality Session			Online Whiteboard Session			t	Cohen's D
	N	Mean	SD	N	Mean	SD		
Quantity	3	9.66	0.47	3	9	2.1	0.42	0.42
Quality	29	2.89	0.92	29	2.68	0.64	0.97	0.26
Ease of use	3	15.66	1.69	3	18.33	1.24	-1.78*	1.8
Usefulness	3	6.66	2.05	3	11	0.81	-2.77**	2.78
*p<0.1, **p<0.05								

5. Discussion

According to the results of the experiment, the students seem to prefer the online whiteboard over the VR. They also mentioned the challenges they had using VR headsets while they mentioned being comfortable with the online whiteboard since they are familiar with web technologies. Even though using VR students reported facing difficulties with the VR and taking longer time to write and attach the sticky notes, they still could generate as many ideas as on the web-based session. When VR becomes more a normal way of communication, in other words, if the students become more familiar with VR, it is highly possible that the students will contribute more ideas in the virtual realm.

There are limitations in this study as the students are more familiar with using computers and the web than VR headsets. The results would be more accurate if the students are familiar with both technologies. In the near future, we plan to conduct several experiments with different groups of participants and with different levels of VR experiences to confirm the validity of this experiment and our assumption about the number of ideas that might be increased when the students are more comfortable with VR.

6. Conclusion

This paper presents a preliminary study in which we compared brainstorming in the VR to brainstorming on a web-based online whiteboard to determine how each communication style influences students' creative thinking. We asked graduate students to brainstorm in the VR using VR

headsets and brainstorm on the web using an online whiteboard and video call. The students reported that the ease of use in VR is lower than in the web-based session. However, they could produce the similar number of ideas with similar quality.

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