Harnessing virtual reality for management training: a longitudinal study

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Abstract

Purpose – Virtual reality (VR) technologies have been gaining popularity in training and development in many fields to promote embodied training. However, its adoption in management has been slow and rigorous empirical research to understand its impact on learning and retention is scarce. Thus, this paper aims to examine the benefits of VR technologies for management training.

Design/methodology/approach – Through a longitudinal experiment comparing VR platforms and a traditional video platform, this study examines two as yet unexplored benefits of VR technologies *vis-à-vis* management training – the cognitive outcome and affective reaction of the training experience over time.

Findings – This study finds that, for cognitive outcomes, immediate gains are similar across video and VR platforms, but subsequent knowledge retention is significantly higher for VR platforms. In terms of affective reaction, VR platforms generate significantly more enjoyment, which carries over to two weeks later, and is partially associated with higher knowledge retention.

Practical implications – This study has implications for management and human resource trainers and system designers interested in integrating VR for training and development purposes.

Originality/value – This study makes a unique contribution by unpacking the long-term benefits of an embodied training system, as well as identify a possible link between cognitive outcomes and affective reaction.

Keywords Human resource training, Virtual reality, Longitudinal study, Embodied learning, Management training

Paper type Research paper

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Introduction

In recent years, there has been an exploding interest in immersive virtual reality (VR) technologies. Technology giants like Meta, Google, Apple and Sony have invested heavily in moving from desktop VR to immersive VR with head-mount displays, fundamentally altering the way people interact with content. The research on VR usage in management and human resource (HR) training has been incommensurate with the increasing popularity of such systems (Schmid Mast, Kleinlogel, Tur, & Bachmann, 2018). Other disciplines, such as medicine, have come to recognize the tremendous promise VR holds for the future. As an example, a randomized double-blinded study found that VR-trained residents performed surgery almost 30% faster and six times less likely to make surgical errors than non-VR-trained residents (Seymour et al., 2002). Similarly, VR usage has been increasing in variety of education and training programs, such as environmental education (Markowitz, Laha, Perone, Pea, & Bailenson, 2018), science and engineering (Potkonjak et al., 2016), mindfulness training for increased decentring (Chandrasiri, Collett, Fassbender, & Foe, 2020), emergency respondents training (Carlson & Caporusso, 2019), virtual chemistry laboratory (Su & Cheng, 2019) and a systematic analysis of VR studies and their impact on learning outcomes in higher education (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020).

The field of business and management, in comparison, has lagged behind in VR application. Although there have been some efforts in combining VR systems into HR training, they are few and far between (Khandelwal & Upadhyay, 2021). Rigorous empirical research to understand its impact on learning is even more scarce. This is despite the fact that management practitioners have already recognized the usefulness and importance of VR technology in areas such as leadership skill development (Chirino-Klevans, 2017) or diversity training in the boardroom (Hinchliffe, 2019). This paper seeks to fill the gap.

The main objective of this study is to assess the impact of immersive technologies on cognitive outcomes, specifically to examine twofold usefulness of VR technology. First, we conduct an experiment to compare how well participants learn concepts through a VR platform versus a traditional video platform (which has been the norm in management training). Second, we investigate the affective reaction from engaging in a virtual learning experience to understand if it offers any superior affective benefits.

Virtual learning through virtual reality technology

VR technology provides a visual representation of a virtual world. The immersive VR technology that we used in this study uses a head-mounted display with head motion tracking and a handset and a computer system control that includes PC-tethered or stand-alone VR headsets. This offers a more immersive experience than 360-degree video viewing. More specifically, immersion, interaction and simulation are the three key features of the VR system examined here.

The experience is *immersive* because the fully enclosed space is devoid of the external physical world environment. Through the head-mounted gear combined with a headphone, users can have 360-degree view of the virtual world integrated with audio content. The VR experience is *interactive* as the sensors can detect user movement and provide corresponding feedback. Users can move inside the virtual world and see a setting from different perspectives. Through a hand console, users can touch and move virtual objects, or even talk to avatars and get responses.

Simulated presence is the third important feature of VR. New technological advances enable designers to make the virtual world in striking resemblance to the real world and can trigger emotional responses in users similar to how they would feel in the real world. For instance, users may feel scared that they would fall off a virtual cliff even though they are fully aware that there is no cliff outside of the VR system.

Immersive and simulated VR's adoption and research in management training and development is scarce. A recent study demonstrated using an immersive VR application in the field of HR training (Ventura, Cardenas, Miragall, Riva, & Baños, 2021). It examined the 360-degree video-based experience in sexual harassment training and found it to be far superior in increasing empathy and perspective taking toward a victim of sexual harassment. However, more research is needed to understand the learning and long-term retention benefits of this new technology in management.

Theory of embodied learning

Embodiment is an emerging cognitive sciences theory that emphasizes the connection between knowledge and the activity of our bodies. The unifying framework captures cognitive linguistics, perceptual symbol theory, action-based theories and emotions in the social psychology literature (Glenberg, 2010). In particular, we draw from the action-based theory that highlights the role of sensorimotor activity in human mental processing. Cognition is not only a result of our neural systems but is also affected by the bodily states such as movement, shape and scale (Barsalou, 2008). Evidence shows that movement has beneficial effects on memory and hippocampal neurogenesis, as well as executive function, the prefrontal cortex and anterior cingulate cortex (Madan & Singhal, 2012).

An interesting brain magnetic resonance imaging (MRI) study demonstrated how cognition is embedded in the action of the body (Hauk, Johnsrude, & Pulvermüller, 2004). When participants heard words relating to various body parts (e.g. pick, lick, kick), their brain's sensorimotor areas corresponding to those movements were found to be activated. Another MRI study observed similar concept-body integration (Boulenger, Hauk, & Pulvermüller, 2009). When participants silently read abstract statements containing action words such as "John grasped the idea" or "Pablo kicked the habit," it activated areas of the brain associated with the arm or leg along with the area for language processing. These studies suggest that our higher-order conceptual knowledge is deeply grounded in the action-perception system.

Many areas of our knowledge, abstract concepts included, have close connections with body movements. It can be argued that our knowledge is inherently embodied. Similarly, Alibali and Nathan (2012) argue that abstract contents such as mathematics are based on actions and grounded in the physical environment. Experiments have shown that gesturing can facilitate the acquisition of new knowledge. For instance, children who were taught to produce hand gestures while solving a math problem learned better than those who were not taught to make any gestures (Goldin-Meadow, Cook, & Mitchell, 2009).

In recent years, theories of embodiment have received increasing attention as new virtual learning technologies tap into the body movement and perception (Lindgren & Johnson-Glenberg, 2013). Immersive experiences allow users to be inside a setting and align the body movement with the environment. While embodied learning can occur without advanced technologies, VR platforms are well suited to promote embodied learning as they combine the physical movement and a virtual environment in new ways.

Hypothesis development

Learning activities can be classified into three categories: cognitive, affective and metacognitive activities (Vermunt, 1996). Cognitive activities include comprehension, analysis, memory and application of knowledge. Affective activities include learners' subjective perception of the learning experience, emotion, satisfaction and attitude.

Metacognitive activities refer to planning, evaluation and reflection. Similarly, learning outcomes can be cognitive or skills based (Kraiger, Ford, & Salas, 1993). This study focuses on cognitive learning outcomes as well as affective reaction and also attempts to explore the relationship between the two.

Cognitive outcome: learning gain

There are two opposing perspectives on the potential of learning gain in a virtual environment. Theories of embodied learning suggest that bodily movements congruent with the learning materials is beneficial for knowledge acquisition and recall. Researchers of gestures, in particular, have found evidence that motor representation of the body plays an important role in retrieving existing knowledge and comprehending new information (Saltz & Donnenwerth-Nolan, 1981). When people gesture and perform actions along with a speech, the information encoded in that speech is more memorable than without gesture (Cook, Mitchell, & Goldin-Meadow, 2008; `Stevanoni & Salmon, 2005).

Different theories seem to offer competing predictions about whether immersive technologies would aid or hinder learning. At the time of VR exposure, embodied learning could lead to learning advantage, but that may be outweighed by extraneous processing of vivid details and subsequent cognitive overload (Makransky et al., 2019). After examining the influence of three levels of audiovisual immersive technology using two-week long intersession intervals, Pollard et al. (2020) found performance on directional bearings as a U-shaped relationship with level of immersion, suggesting that higher levels of immersion may not always improve learning. In an experiment examining how embodied systems affect learning of physics knowledge, Johnson-Glenberg, Megowan-Romanowicz, Birchfield, and Savio-Ramos (2016) found that although immediate learning appeared to be the same across different systems, users of high embodiment systems were able to retain more knowledge after a week and better apply it to new problems, thus exhibiting better transfer of training. Similarly, studies on children found that gesturing during the instruction helped them to retain knowledge better, suggesting that movement "makes learning last" (Cook et al., 2008).

Therefore, we hypothesize that immediate cognitive learning outcomes will be similar for low- and high-embodied conditions. However, over the long run, the extraneous processing ceases, whereas the benefits of embodied learning may endure leading to VR participants to remember more over time.

H1a. The immediate learning gains after the instruction will be similar in both low- and high-embodied platform.

H1b. The learning retention at a follow-up test will be higher in a high-embodied platform than in a low-embodied platform.

Affective reaction: enjoyment

Much of the literature on embodied learning focuses on cognitive outcomes, but not enough attention has been paid to affective reaction. Existing studies have shown that users of a VR instructional platform find it entertaining and fun (Beltrán Sierra, Gutiérrez, & Garzón-Castro, 2012), and that this positively influences their motivation to continue using the tool (Gallego, Bueno, & Noyes, 2016). Thus, in this study, we focus on enjoyment as an element of affective reaction.

Three key factors make immersive VR experience an enjoyable one. First is enhanced simulation. Empirical studies have exhibited increased interest, engagement and perceived effectiveness from incorporating simulation into management teaching (Keys & Wolfe, 1990; Lu, Hallinger, & Showanasai, 2014). As a new simulation technology, immersive VR not only offers the same value but also provides additional benefits because of its enhanced technical features. Second, immersive VR has been consistently demonstrated to induce greater sense of presence among users than traditional desktop environment (Bailey, Bailenson, Won, Flora, & Armel, 2012; Makransky et al., 2019; Moreno & Mayer, 2002). Presence (place presence, social presence and copresence) is the psychological experience of "being there," and it leads to higher satisfaction of the learning experience (Bulu, 2012; Vrellis, Avouris, & Mikropoulos, 2016). Third, the novelty of this emerging technology adds to the appeal for users, though some argue that with widespread use it is likely to fade over time (Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017).

A combination of enhanced simulation, presence and novelty can contribute to a more enjoyable and preferable experience in an immersive VR environment. We therefore hypothesize more positive experience with the VR platform in self-reports of enjoyment.

H2. The experience of a high-embodied platform will be more enjoyable than the experience of a low-embodied platform.

Enjoyment and learning retention

Both theory and empirical evidences suggest that positive emotions enhance learning through the mediating effect of increased motivation. In addition to advances in motivational theory (Renninger & Hidi, 2016; Wentzel & Miele, 2009), several emerging theoretical perspectives also point to the important role of positive affect on learning. Some examples include the control value theory of achievement emotions (Pekrun, 2000), cognitive affective theory of learning with media (Moreno & Mayer, 2007) and affective computing (Picard, 1997). They argue that positive emotions are likely to increase the "interest and motivation to learn" (Pekrun, 2006, p. 326). And motivation has been found to have positive effects on virtual learning (Benbunan-Fich & Hiltz, 2003; Piccoli, Ahmad, & Ives, 2001; Salzman, Dede, Loftin, & Chen, 1999). In some recent empirical studies, structural equation models have shed light on an "affective path" where VR features increased presence and motivation, which in turn improves learning results (Ai-Lim Lee, Wong, & Fung, 2010; Makransky & Petersen, 2019).

The impact of positive affect on learning can potentially occur at two different junctures in the learning process: the initial knowledge acquisition, subsequent knowledge retention or both. An experiment demonstrated that positive emotions at the time of initial learning had not improved subsequent recall (Isen, Shalker, Clark, & Karp, 1978). During the study, participants were induced with either positive or negative affect before being asked to learn a list of words. They then were induced with positive or negative affect again with a different set of stimuli before a recall test. The difference in recall was attributable to the affective state at the time of recall, regardless of the affective state at the time of knowledge acquisition. This study suggested a need to examine affect beyond the initial learning stage, and that long-term retention could be related to learners' emotional state at the time of recall, not just at the time of knowledge acquisition.

We hypothesize that enjoyment has a positive impact on immediate learning and subsequent retention. When people feel good about the learning experience, they are more likely to remember the content over a longer period.

H3a. Participant enjoyment at the time of learning is positively correlated with the immediate learning gain.

H3b. Participant enjoyment at the time of follow-up is positively correlated with the learning retention.

Methods

Experimental design and virtual reality apparatus

We conducted an experiment to assess how well participants learned statistical concepts, as a representation of an example of abstract conceptual learning that can be found in management, via different instructional platforms. There were three conditions varying by the level of embodiment of the platform. The low-embodied condition (Video) used a video with Excel demonstration viewed from a laptop. The medium-embodied condition SVR (Static VR) utilized a VR demonstration viewed from a head-mount display, and the high-embodied condition EVR (Exploratory VR) used the same equipment as the medium-embodied condition but with the addition of handheld controls to manipulate freely the VR dataset at the end of the instruction. Plate 1 shows participants in the SVR and EVR conditions during the experiment. Instructions in all three conditions were recorded by the same speaker, following the same script, using the same data set and covering the same length in time.

The VR system used in this experiment was the Oculus Rift S, a PC-tethered head-mounted display. The Rift S allows users to move with six degrees of freedom, which refers to tracking display movement in three-dimensional space with forward/backward, up/down and left/right moves around three perpendicular axes. Accordingly, the user's position changes in virtual space reflect their movement in the physical world. The Rift S is navigated with two controllers, which the user can see in VR. In this experiment, the EVR group interacted with a virtual laser pointer that they could use to select various objects and menus in the virtual space.

Participants, procedure and measures

Seventy-five undergraduate sophomore business students enrolled from a private university in the USA participated in the experiment. In total, 38 were male (51%) and 37 were female (49%). Students received information about a study on technology platforms and learning outcomes for basic statistics and were asked to sign up. All participants were each given a $5 Starbucks coupon and entered into a lottery with five winners each receiving

Plate 1.
Participants in EVR and SVR conditions

\$100. Participants were randomly assigned to one of the three conditions, with 25 participants in each condition. First, the participants were given a pretest to assess their self-reported familiarity with statistics and with the technology of their experimental platform (e.g. VR or Excel). They were also given three statistical questions to objectively assess their baseline statistics knowledge.

Participants in the SVR condition watched a recorded 8-min instruction on statistical concepts using a real estate price data set. Afterward, they were given 12 multiple choices questions to assess their understanding of concepts explained in the session. They were then asked about how much they enjoyed the session and how much they enjoyed the data presentation. The only difference for participants in the EVR condition was that they were given 5 min after the instruction to use their handheld controls to freely manipulate the data set in the VR environment. In the Video condition, the participants watched an 8-min recording on the computer. The video covered the same content as the VR video with Excel illustration. Participants in all conditions received the same pretest and posttest. They were also given an online follow-up survey 15 days later. It contained the same statistics and subjective questions as the posttest. In total, 62 of the 75 subjects (83%) participated in the follow-up test (21 for Video, 22 for SVR, 19 for EVR).

Results

Participants' pretest responses were compared to validate initial equivalence between conditions. ANOVA showed no significant difference across conditions on either self-reported statistics proficiency or the objective test from three statistical questions (see Table 1). Participants reported significantly higher proficiency with Excel than with VR, but the two VR groups had similar level of familiarity with the technology ($t(48) = 0.77, p > 0.10$).

To test *H1a*, a measure of immediate learning gain was constructed by the difference of the participant score on the three pretest statistics questions from the scores on the same questions at posttest ($M_{\text{EVR}} = 0.80$, $\text{SD}_{\text{EVR}} = 2.08$, $M_{\text{SVR}} = 1.04$, $\text{SD}_{\text{SVR}} = 1.93$, $M_{\text{Video}} = 1.28$, $\text{SD}_{\text{Video}} = 1.51$). ANOVA results showed no significant difference among three groups on immediate learning gain, $F(2, 72) = 0.42$, $p > 0.10$. *H1a* was supported as the immediate learning gain was similar in high-, medium- and low-embodied platforms.

To test *H1*b on learning retention, we constructed a measure of learning retention by the difference between posttest and follow-up test on 12 statistical questions. There was a general learning loss across all conditions, as negative retention score indicates loss in knowledge (M_{EVR} −1.58, $M_{\text{SVR}} = -0.82$, M_{Video} −3.52, M_{Total} −1.97). ANOVA analysis showed a significant difference between groups ($F(2, 59) = 3.24$, $p < 0.05$). Eta squared was 0.099, indicating a medium to large effect size. Post hoc tests suggested significant difference between SVR and Video conditions (see Table 2). Participants in the Video group experienced more than four times the learning loss as those in the SVR group. There was no

Table 1. ANOVAs to validate initial equivalence between conditions

Variable	Mean (SD) Low-embodied (Video)	Medium-embodied (SVR)	High-embodied (EVR)	*F*-test	*p*-value
Statistics: self-reported	4.28 (1.40)	4.76 (1.33)	4.56 (1.19)	0.85	0.434
Statistics: objective	3.76 (1.45)	3.68 (1.38)	3.92 (1.68)	0.16	0.849
Platform familiarity	4.76 (1.14)	2.60 (1.61)	3.00 (2.06)	11.71***	0.000

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. $N = 75$

significant difference between SVR and EVR in retention. Figure 1 shows the comparison of immediate learning gain and retention by condition.

To understand affective reaction to the learning experience, we asked participants to rate how much they enjoyed the session and the data presentation. The same assessments were taken at posttest and follow-up. Responses to the two questions were highly correlated (r = 0.72 at posttest, r = 0.78 at follow-up). Paired t-test showed that reported enjoyment for the three groups all decreased significantly over two weeks (session enjoyment $M_{\text{post-test}} = 5.15$, $M_{\text{followup}} = 4.50$, $t(61) = 3.75$, $p < 0.001$; data presentation enjoyment $M_{\text{post-test}} = 5.44$, $M_{\text{followup}} = 5.00$, $t(61) = 3.13$, $p < 0.01$). ANOVAs showed that both measures of enjoyment at both times differed significantly across conditions (see Table 3). Post hoc Tukey tests showed that at posttest, participants in VR conditions enjoyed the session much more than

Table 2.
Descriptive statistics and ANOVA for learning retention score at follow-up

Condition	*N*		Mean		SD
EVR	19		−1.58		4.30
SVR	22		−0.82		3.25
Video	21		−3.52		3.16
Total	62		−1.97		3.70
	Sum of squares	df	Mean square	*F*	Sig.
Between groups	82.79	2	41.40	3.24*	0.046
Within groups	753.14	59	12.77		
Total	835.94	61			
(I) Group	(J) Group		Mean difference (I − J)		Sig.
EVR	SVR		−0.76		0.776
	Video		1.94		0.207
SVR	EVR		0.76		0.776
	Video		2.71*		0.042
Video	EVR		−1.94		0.207
	SVR		−2.71*		0.042

Notes: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

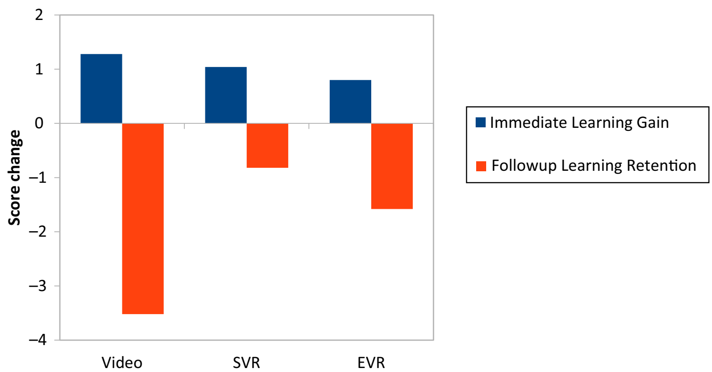


Figure 1.
Immediate learning gain and learning retention by condition

Notes: Immediate learning gain was calculated based on three questions between pretest and posttest. Learning retention was calculated based on 12 questions between posttest and follow-up test those in the Video condition with no significant difference between SVR and EVR. Enjoyment of the data presentation yielded the same result: Video participants enjoyed it much less than those in SVR and EVR conditions, and the two VR conditions had similar ratings. The same results were found at follow-up test, that is, participants in the Video condition enjoyed the session and the data presentation significantly less than both VR conditions, and there was no significant difference between SVR and EVR participants. *H2* was partially supported in that low-embodied Video platform was experienced as significantly less enjoyable, but there was no difference between medium- and high-embodied conditions.

To test the relationship between affective reaction and cognitive learning outcomes in *H3a*, Pearson correlation was calculated between enjoyment at the time of learning (i.e. posttest) and immediate learning gain. The correlation was not significant ($r = -0.15$, $p > 0.10$ for session enjoyment, $r = -0.75$, $p > 0.10$ for data presentation enjoyment). *H3a* was not supported as there was no significant relationship between enjoyment at the time of learning and immediate learning gain.

For *H3b*, similar Pearson correlation was calculated between enjoyment and learning retention score. At the time of recall, enjoyment of the data presentation was significantly correlated with retention ($r = 0.27$, $p < 0.05$), whereas enjoyment of the session had no significant correlation ($r = 0.20$, $p > 0.10$). *H3b* was partially supported. At the time of recall, participants who enjoyed the data presentation more were able to retain more of the initial learning.

Discussion

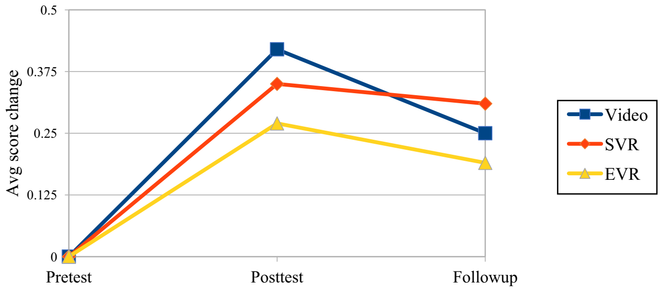
Through a longitudinal experimental design, the study compared three instructional platforms with varying degrees of embodiment. Several key findings have emerged. First, the study showed that an immersive VR platform produced longer lasting learning benefits than traditional video platforms. This is extremely important to note because traditional HR training has been relying on video platforms as the main medium of training. All platforms achieved similar level of immediate learning gain post instruction. However, participants in the Static VR condition experienced significantly higher retention two weeks afterward (see Figure 2).

Second, subjective experience of VR instructions was significantly more enjoyable than the traditional video format, and the enjoyment advantage persisted after two weeks. Moreover, there was evidence suggesting a relationship between enjoyment and learning retention. Correlation tests showed participants expressing higher enjoyment at the time of recall were

		Mean (SD)			
Outcome	Low-embodied (Video)	Medium-embodied (SVR)	High-embodied (EVR)	*F*-test	*p*-value
Enjoy the session					
Posttest	3.96 (1.62)	5.88 (1.27)	5.68 (1.46)	13.10***	0.000
Follow-up	3.43 (1.50)	4.95 (1.25)	5.16 (1.46)	9.33***	0.000
Enjoy the data presentation					
Posttest	4.48 (1.66)	6.04 (1.14)	5.56 (1.47)	7.69***	0.001
Follow-up	3.76 (1.67)	5.64 (1.09)	5.63 (1.54)	11.64***	0.000

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $N_{\text{post-test}} = 75$. $N_{\text{follow-up}} = 62$

Table 3. Descriptive statistics and ANOVAs for affective reaction



Notes: Average score change per question at posttest was calculated as the average of immediate learning gain based on three questions between pretest and posttest. Average score change per question at follow-up was calculated as the average of learning retention scores based on 12 questions between posttest and follow-up test

Figure 2.
Learning gain and learning retention per question over time

also able to better retain their initial learning. Consistent with findings from previous research (Isen et al., 1978), enjoyment at the time of learning had no relationship with learning gain. It was positive emotions at the time of recall that were associated with better retention.

Lastly, we hypothesized that cognitive learning outcomes and affective reaction would be different between medium-embodied SVR and high-embodied EVR conditions. Results suggested that neither immediate learning gain nor retention was significantly different. Assessment of enjoyment did not differ significantly either. Based on the cognitive theory of multimedia learning theory (Mayer, 2005, 2009), VR platforms may cause cognitive overload through extraneous processing and hinder learning as a result. It can be argued that the potential benefits of high-embodied EVR setup may have been offset by the additional mental resources required when participants were manipulating the virtual environment with the controllers after the instruction. Another explanation could point to the research design where physical movement of handheld controls was only available to the participants after instruction in the EVR condition. This hand movement was open to individuals for voluntary exploration of the VR data set without any monitoring. As a result, the movement may have not been sufficient in an overall magnitude across all participants to show a different impact on learning from the other conditions. It could also be plausible that the participants may have been distracted by playing with a novel handheld device at the end and failed to remember principles of statistics taught earlier. The impact of recency bias could have been at play here and a worthy pursuit for further exploration.

Theoretical and practical implications

This study makes several contributions both to the embodied learning theory and its applications. This is the first study that investigates the superiority of VR platforms for measurable retention of abstract concepts in addition to subjective experiences. Another theoretical contribution comes from the longitudinal design for exploring learning outcomes over time. Although we did not observe an immediate learning advantage, we did find longer lasting learning outcomes for the VR platform (Pollard et al., 2020). This study also contributes to the research on affect and learning. Most models of virtual learning primarily focus on cognitive outcomes. While VR platforms did not improve cognitive outcomes immediately after instruction, they produced more enjoyable experience, which was positively associated with better retention over time. Future research is needed to understand how to elicit certain emotions in the virtual learning environment, how to manage the evolution of the emotional reaction over time and how both the immediate emotional reaction and longitudinal change in emotional response can facilitate learning.

This study demonstrates that VR learning platforms can be a valuable tool for management and business training. VR system can not only improve affective reaction to the learning experience but can also keep learners motivated to retain knowledge. The study can enlighten educators to use carefully design VR application for other than statistics content such as sustainable operations and decision-making and can even be useful for other management skills and training such as giving feedback, sexual harassment or ethics training or even new employee orientations. Educators can create technical features and cognitive contents to make remote learning more effective and affective. Certain elements of the system can be designed to elicit lasting emotions to facilitate learning (Plass & Kaplan, 2016).

Limitations

This study seeks to shed light on how VR platforms impact cognitive learning outcomes and affective reactions with several limitations. First, the study participants were college students. People of different age groups may interact and learn differently in embodied systems. Second, enjoyment from VR could be associated with the novelty of the technology. Majority of the participants not familiar with VR may have been more likely to experience excitement. Whether enjoyment would diminish as a result is a question for further study. Finally, the longitudinal approach of this study has offered some interesting insights about knowledge retention, and even a longer time frame could reveal different dynamics.

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