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Immersive virtual reality versus interactive video: comparing the impact on learning outcomes, motivation, and engagement among college students

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Immersive virtual reality (VR) and interactive videos represent two forms of interactive multimedia utilized in education. Immersive VR, a relatively recent addition to educational technology, has gained attention with the advent of affordable commercial solutions and claims about its learning effectiveness. This study investigates and compares their impact on college students' learning outcomes, motivation, and engagement. A total of 132 students participated in either immersive VR or interactive video learning experiences. Data were collected through pre- and post-knowledge assessments and self-report surveys measuring motivation and engagement. Findings revealed that participants in the immersive VR learning experience group exhibited significantly higher motivation and engagement than participants in the interactive video group. However, they achieved significantly lower learning outcomes than those in the interactive video group. Moreover, while motivation and engagement were positively correlated, neither factor showed a significant relationship with learning outcomes.

Keywords: immersive VR; cognitive load; learning experience; higher education; multimedia learning

Introduction

Immersive virtual reality (VR) and interactive video are two forms of interactive multimedia that are increasingly adopted in education to enhance learner engagement, motivation, and comprehension of complex concepts. These technologies empower learners by providing control over the learning environment and encouraging active participation (Cairncross & Mannion, 2001; Sims, 1997). Interactive videos have been used in education for many years to engage and motivate learners and enhance learning outcomes (Preradović et al., 2020). In contrast, immersive VR, a relatively recent addition to educational technology, has gained increased attention (Di Natale et al., 2020; Snelson & Hsu, 2020) driven by the increased availability of affordable commercial VR solutions (Parong & Mayer, 2018; Wu et al., 2020) and the claims regarding its learning effectiveness (Lawson et al., 2024).

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Immersive VR technology not only fosters engagement through interactivity but also creates a highly immersive experience that can enhance learning outcomes. By simulating a realistic world and isolating users from external distractions, immersive VR fosters a sense of presence and enables learners to focus deeply on the content (Cummings & Bailenson, 2016; Mikropoulos & Natsis, 2011). This deep absorption of the material has the potential to enrich the overall learning experience. However, the effectiveness of immersivity in learning, and whether the combination of interactivity and immersivity outperforms interactivity alone remains an area that requires further exploration.

This study addresses this gap by comparing learning outcomes, motivation, and engagement between immersive VR and interactive videos. Investigating this distinction is crucial as interactive learning techniques can be found in both VR and other conventional media, making it difficult to isolate the unique benefits of VR. The aim of this media comparison study was to evaluate how effectively university students learn the same material when it is presented through two different multimedia technologies. The findings of this study have substantial practical implications, particularly for resource allocation in educational settings. The growing emphasis by technology companies on investing in immersive VR educational programs has created increased interest among educators (Checa & Bustillo, 2020; Di Natale et al., 2020). Therefore, there is a growing need to assess the value of such investments. This research provides insights into whether immersive VR, despite its substantial costs, complexity, and time requirements (Liu et al., 2022), delivers unique educational benefits or if more accessible and cost-effective approaches, such as interactive videos, can achieve comparable outcomes.

Immersive and interactive affordances

The learning experience offered by immersive VR technology is unique, as it allows learners to feel a profound sense of presence within 3D computer-generated settings (Liu et al., 2022; Steuer, 1995). This presence can trigger situational interest, increasing learner engagement (Huang et al., 2021; Johnson- Glenberg et al., 2021; Makransky & Petersen, 2021) and enjoyment compared to traditional video formats (Makransky et al., 2021). Learners in immersive VR environments also demonstrate high levels of motivation and engagement compared to learners exposed to traditional slideshow presentations of the same material (Parong & Mayer, 2018), which may lead to increased focus and effort directed toward learning (Huang et al., 2021).

Despite these advantages, research results regarding the impact of immersive VR on learning outcomes are not entirely consistent (Mayer & Bailenson, 2024; Parong & Mayer, 2021; Queiroz et al., 2022). Wu et al. (2020) conducted a meta-analysis of 35 studies and found that immersive VR learning environments are more effective in improving learning outcomes among K–12 students compared to desktop VR and traditional instruction. Nonetheless, immersive VR may introduce extraneous cognitive load due to environmental distractions, potentially leading to a negative effect on learning outcomes (Makransky, Borre-Gude, & Mayer, 2019). For example, Parong and Mayer (2018) found that students achieved better learning outcomes with slideshow presentations compared to immersive VR experience. Furthermore, although immersive VR is associated with a heightened sense of presence, engagement, and motivation, these benefits do not always translate to improved learning outcomes when compared to less immersive methods (Lawson et al., 2024; Makransky et al., 2021).

Moreover, adding interactivity may enhance learning by fostering self-directed learning that creates a sense of agency and autonomy (Deci & Ryan, 2015). When immersive VR includes interactive elements, it allows learners to exert control over the learning environment, enabling them to manipulate and engage with the content (Johnson-Glenberg et al., 2021), which can enhance motivation and engage learners in higher cognitive processing (Al-Khiami et al., 2024; Keller et al., 2025; Makransky & Petersen, 2021). However, increased control and interactivity in an immersive environment can complicate the learning environment and increase cognitive load, which may negatively affect the learning process (Makransky, Borre-Gude, & Mayer, 2019; Makransky et al., 2021; McGivney, 2025).

While immersive VR offers a high degree of interactivity, active learning is also possible in conventional media, such as interactive videos (Lawson et al., 2024). Interactive videos offer more than passive content delivery (Preradović et al., 2020). They allow students to engage with content by taking notes, highlighting key points, or answering embedded questions (Dodson et al., 2018). In addition, interactivity within videos can foster motivation, support self-paced learning, and enhance the learning experience by encouraging active participation and cognitive engagement (Yoon et al., 2021). Furthermore, higher levels of interactivity (e.g. prompting questions, giving feedback, and allowing learner control) have been associated with improved learning outcomes (Wetzel et al., 1994).

The literature comparing immersive VR and interactive video learning experiences and their impact on learning outcomes is limited, and the results are inconclusive (Mayer & Bailenson, 2024). Parong and Mayer (2021) conducted a study comparing the impact of immersive VR versus interactive video on learning outcomes for undergraduate students. Both experiences contained identical content, images, and interactive elements. The study revealed that students who participated in the interactive video condition demonstrated significantly better knowledge transfer compared to students in the immersive VR condition. However, no significant differences were observed in knowledge retention, interest, or motivation between the two groups.

Adding to these mixed findings, Queiroz et al. (2022) conducted two studies comparing knowledge acquisition and self-efficacy among middle school girls learning science through either immersive VR or 2D video. In the first study, immersive VR showed a higher impact on self-efficacy but did not result in better learning outcomes compared to the 2D video. In the second study, immersive VR led to better learning outcomes but did not improve self-efficacy compared to the 2D video. These results suggest that the benefits of immersive VR may vary depending on the learner population or learning context. To further explore the role of interactivity, Johnson-Glenberg et al. (2021) examined how varying levels of interactivity in immersive VR and 2D desktop video affected undergraduate learning outcomes. Their results indicated that higher interactivity significantly enhanced learning compared to lower interactivity. Additionally, students in the immersive VR condition reported significantly higher levels of engagement, underscoring the impact of immersion on the overall learning experience.

Theoretical framework

The theoretical framework of this study is based on the cognitive theory of multimedia learning (CTML) (Mayer, 1997). The CTML suggests design principles that must be employed when developing multimedia instruction to enhance learning (Mayer, 2009). Based on the CTML, the learner is engaged in three cognitive processes during learning: extraneous processing, essential processing, and generative processing (Makransky et al., 2021; Mayer, 2009). The learner encounters extraneous processing when the learning environment is poorly designed or there are distractions in the environment. The learner engages in essential processing if the learning content is complicated, while generative processing is occupied when the learner is engaged and making sense of the material, which is when learning occurs (Makransky et al., 2021). Due to the limited cognitive processing capacity, a learning experience that overloads the learner with extraneous processing will leave essential and generative processing, which is necessary for meaningful learning to happen, without enough capacity (Makransky, Borre-Gude, & Mayer., 2019; Makransky et al., 2021; Mayer & Chandler, 2021).

Many aspects of immersive VR require extraneous processing, such as navigating a 3D environment, figuring out the control interface, or being inexperienced with the technology, which could make it more challenging to understand and comprehend the content and gain knowledge from the experience (Makransky, Borre-Gude, & Mayer, 2019; Makransky et al., 2021). On the other hand, the high sense of presence that learners feel in an immersive VR environment may engage and motivate them in the learning process. Being engaged and motivated provides more cognitive capacity for generative processing, which leads to better understanding and enhances learning outcomes (Makransky, Borre-Gude, & Mayer, 2019). In addition, the interactivity affordance of immersive VR and interactive videos, when appropriately designed and developed, enables learners to actively engage in selecting, organizing, and integrating new information through embedded activities, which encourages essential and generative processing (Johnson-Glenberg et al., 2021; Moreno & Mayer, 2007), leading to better understanding of the learning content.

This study contributes to our understanding of the educational potential of immersive VR and interactive videos by exploring the interplay between interactivity, immersivity, and learning outcomes. This study addresses three primary research questions within the context of the industrial history of a watershed:

1. To what extent does learners' industrial history content knowledge differ in the immersive VR experience from the interactive video experience?
2. How do learners' motivation and engagement differ in the immersive VR experience from the interactive video experience?
3. To what extent do students' industrial history content post-assessment scores, motivation, and engagement correlate?

Methods

This study included two experimental groups. Data were collected using pre- and post-assessments to evaluate knowledge gain, along with self-report surveys to measure motivation and engagement for both groups (discussed below). All questionnaires were created in REDCap (Research Electronic Data Capture), with responses automatically submitted to the database.

Participants

Participants were recruited from East Coast U.S. universities using a convenience sampling method. A total of 132 students participated in the study. The immersive

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VR group consisted of 61 participants (31 females, 30 males). The interactive video group consisted of 71 participants (33 females, 38 males). All participants were 18 years or older. Recruitment was conducted via email outreach to universities' clubs and academic programs. Multiple sessions were organized for the immersive VR experience, while a link to the interactive video experience was shared with professors and club leaders to distribute to students. The study received ethical approval from the Institutional Review Board at the authors' university.

Learning experience

The learning intervention encompassed two comparison groups: one using a headset-based immersive VR and the other using an interactive video. The learning experience, 'watershed explorers: industrial history', focused on the industrial heritage and environmental impact on a watershed located in the United States. It is a shortened version of watershed explorers, an immersive VR experience featuring nine locations, each with two to three 360° photospheres (Araujo-Junior & Bodzin, 2024). The abbreviated version follows a river journey through seven distinct watershed locations, where participants explore content along with historical and contemporary imagery through 360° photospheres featuring embedded interactive media at each site. These locations are central to the region's industrial past and continue to shape its environmental landscape today. The experience in each condition takes approximately 20 minutes to complete.

Both experiences were identical in interface structure, content, and design features. The only difference between the two conditions was the medium of delivery. Neither included voice narration; instead, background music and nature sounds accompanied the experience. Historical information was presented as on-screen text in a dialog box alongside a visual avatar (see Figure 1a and 1b). To support navigation, on-screen guidance was provided in both experiences to help learners locate the embedded interactive elements that included images and videos within the environment. An introductory tutorial at the beginning of the experience provided all necessary instructions for navigation and interaction, enabling participants to explore the content independently without external assistance. The experience was designed to promote self-directed exploration, allowing learners to proceed at their own pace and interact with elements in any order. Additionally, all accessed information and images were automatically collected in a digital journal, a built-in feature that compiled visited content in one place, which participants could refer to at any time during the experience.

Immersive VR participants wore a Meta Quest 2 headset, with the learning experience preloaded on the device, allowing a wireless, standalone experience. They were able to freely move their heads to explore and identify interactive elements in each location and interact with them using the handheld controllers. Conversely, participants in the interactive video experience used their personal computers. They panned around the photosphere using a mouse to locate and interact with the embedded elements. To maintain participant engagement, both conditions included identical knowledge check questions that were presented after viewing the information at each location in both conditions.

Instruments

A demographic survey was used to collect information related to gender, age, and ethnicity. To assess learning outcomes, participants completed a content knowledge test before and after the learning experience. The measure was developed by the researchers and validated by experts in the fields of environmental science and social studies who are familiar with the watershed locations. The learning outcomes measure consisted of 14 multiple-choice questions related to the information presented in the learning experience. Each question included four response options. Students earned one point for each correct answer, for a total possible score of 14 points.

To measure engagement, an adapted version of the Science Engagement Scale originally developed for 6th–8th grade students (Chung et al., 2016) was used. Six of the original eight items were selected for this study. To enhance response granularity, the rating scale was adjusted from the original 4-point Likert scale to a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Survey items

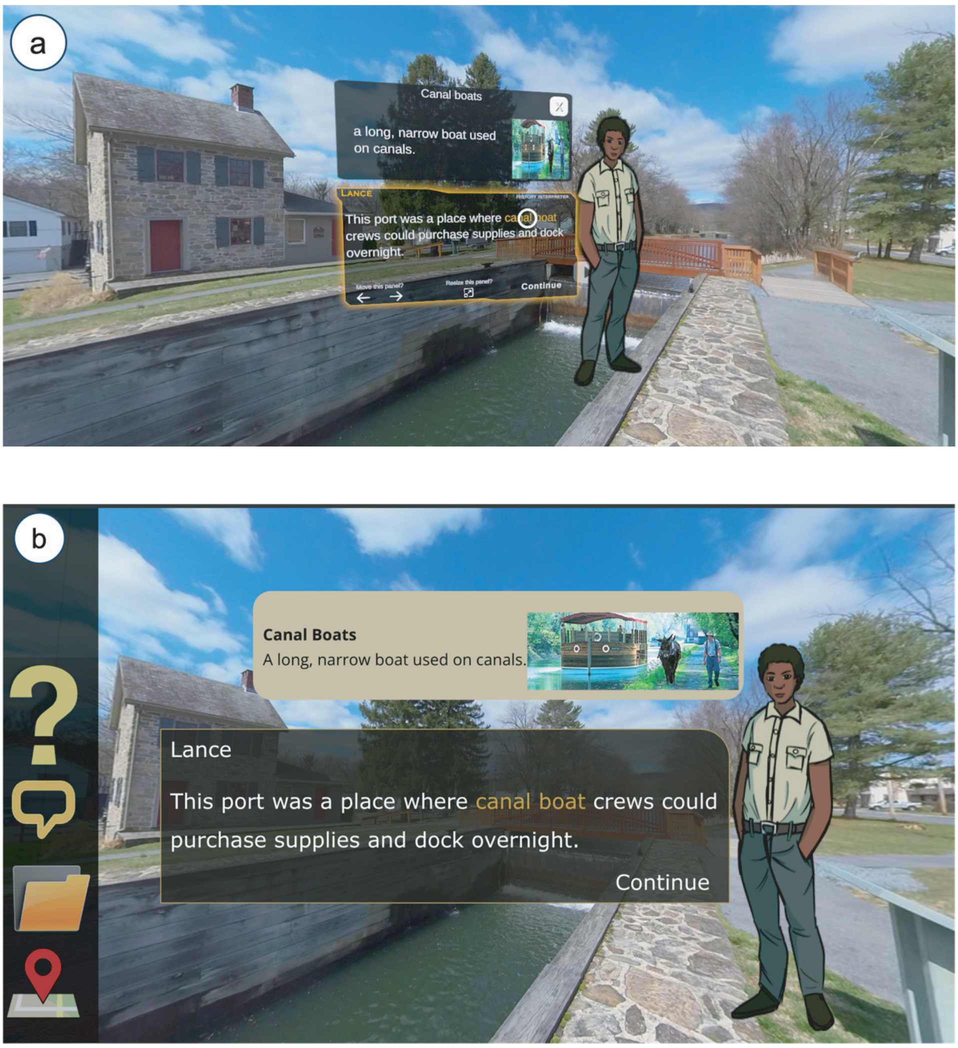

Figure 1. Avatar presenting historical information.

Note: The avatar is presenting historical information in one of the locations. (a) Immersive VR learning experience. (b) Interactive video learning experience.

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were customized for each condition to reflect the specific learning environment. For example, the original item 'During this activity: I was focused on the things we were learning most of the time' was modified to 'I was focused on the virtual environment most of the time' for the immersive VR condition, and 'I was focused on the interactive video experience most of the time' for the interactive video condition. Appendix A presents the full list of engagement items used in both conditions.

To measure motivation, a custom scale was adapted from two validated instruments: the Intrinsic Motivation in e-Learning (IMeL) questionnaire (Fırat et al., 2018) and the Intrinsic Motivation Inventory (IMI) (Lee et al., 2010; McAuley et al., 1989). Four items from IMeL and two items from IMI were selected. Items were modified to reflect the delivery medium used in each condition. For instance, the original IMeL item 'I enjoy studying in e- learning environments' was modified to 'I enjoyed learning in the virtual environment' for the immersive VR, and 'I enjoyed learning from the interactive video' for the interactive video condition. The scale used a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Appendix A provides the full list of motivation items.

Data analysis

The collected data were managed and analyzed using IBM SPSS statistical software version 29. There were no missing data; thus, no imputation or exclusion was necessary. Table 1 displays the descriptive statistics (means and standard deviations) for the dependent measures across the two groups. To assess internal reliability of the study scales, Cronbach's alpha coefficients were computed. The motivation scale demonstrated strong reliability ($\alpha = 0.89$), while the engagement scale showed moderate reliability ($\alpha = 0.67$). Also, a Pearson correlation of $r = 0.42$ was calculated between pre- and post-assessment scores across groups, indicating moderate consistency of responses over time. A chi-square test revealed no significant differences in gender distribution, $\chi^2(1, N = 132) = 6.28$, $p = 0.280$.

A one-way analysis of covariance (ANCOVA) was conducted to examine the effect of instructional method (immersive VR vs. interactive video) on post-assessment scores, while controlling for pre-assessment scores. Prior to ANCOVA, the assumption of homogeneity of regression slopes was tested. The interaction term for group by pre-assessment was not significant, $F(1, 128) = 0.352$, $p = 0.554$. This confirmed that the assumption was met, indicating the covariate (pre-assessment) influenced the dependent variable (post-assessment) similarly across groups. Therefore, it was acceptable to proceed with ANCOVA after removing the interaction term. To assess the significance of the regression after accounting for the group difference, the relationship between pre-assessment (covariate) and post-assessment was tested. Results

Table 1. Means (M) and standard deviations (SD) of the dependent measures for the two groups.

Measure	Immersive VR *M (SD)*	Interactive Video *M (SD)*
Pre-assessment	6.25 (2.28)	7.41 (2.65)
Post-assessment	9.20 (2.01)	11.89 (1.87)
Motivation	4.50 (0.51)	4.08 (0.78)
Engagement	4.14 (0.49)	3.72 (0.64)

revealed that the regression was statistically significant, $F(1, 129) = 19.668$, $p < 0.001$, $\eta^2 = 0.132$, indicating that pre-assessment scores accounted for a substantial portion of the variance in the post-assessment scores.

A one-way multivariate analysis of variance (MANOVA) was also conducted to investigate group differences in engagement and motivation. Prior to the analysis, the assumptions of multivariate normality and homogeneity of covariance matrices were tested. Multivariate normality was assessed through univariate and bivariate normality checks. Skewness (engagement = –0.49; motivation = –1.59) and kurtosis (engagement = 0.35; motivation = 4.30) values indicated univariate normality, with only one kurtosis value for motivation scores exceeding the acceptable range of –2 to +2. Normal probability plots showed relatively straight lines, supporting the assumption of univariate normality. Bivariate normality was verified through scatterplots, which displayed relatively elliptical shapes. Homogeneity of covariance matrices was tested with Box's *M* Test, which was significant ($p = 0.009$), suggesting a violation. However, given the relatively equal group sizes, MANOVA was deemed robust, and Pillai's Trace was used.

To address the third research question, bivariate correlation analyses were conducted within each group to examine the relationships between post-assessment scores, engagement, and motivation.

Results

To examine whether learners' industrial history content knowledge gain differed between immersive VR and interactive video, an ANCOVA was conducted, adjusting for pre-assessment scores as a covariate. The results indicated that the interactive video adjusted mean of the post-assessment scores ($M = 11.735$, $SE = 0.217$) was significantly higher ($p < 0.001$) than the immersive VR group scores ($M = 9.374$, $SE = 0.235$). The effect size was large ($\eta^2 = 0.291$), indicating that approximately 29.1% of the variance in the post-assessment scores was explained by the multimedia group. This suggests that the interactive video was more beneficial for industrial history content learning than immersive VR. Detailed ANCOVA results, including *F*-values, *p*-values, and effect sizes, are presented in Table 2.

To assess whether learners' motivation and engagement differed between the immersive VR and interactive video groups, a one-way MANOVA was conducted. A significant multivariate effect of group was observed on the combined dependent variables (Pillai's Trace = 0.127, $F(2, 129) = 9.39$, $p < 0.001$). Participants in the immersive VR group reported significantly higher motivation ($M = 4.50$, $SD = 0.51$) compared to the interactive video group ($M = 4.08$, $SD = 0.78$), $p < 0.001$. Engagement scores

Table 2. ANCOVA results for the effect of group on post-assessment scores, controlling for pre-assessment.

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected model	301.92	2	150.96	46.11	<0.001	0.417
Intercept	1127.78	1	1127.78	344.47	<0.001	0.728
Pre-assessment	64.39	1	64.39	19.67	<0.001	0.132
Group	172.36	1	173.36	52.95	<0.001	0.291

were also significantly greater for participants in the immersive VR group (M = 4.14, SD = 0.49) than for the interactive video group (M = 3.72, SD = 0.64), $p < 0.001$. These results indicated that immersive VR was more motivating and engaging than interactive video.

To explore the relationship among learners' post-assessment scores, motivation, and engagement within each group, bivariate correlations were calculated separately for the immersive VR and interactive video groups. In the immersive VR group, the analysis revealed no significant correlation between post-assessment and engagement (r = –0.025, p = 0.851) or between post-assessment and motivation (r = –0.209, p = 0.106). However, a significant positive correlation was found between engagement and motivation (r = 0.567, $p < 0.001$), indicating that higher levels of engagement were associated with higher levels of motivation in the immersive VR group.

Similarly, in the interactive video group, post-assessment scores showed no significant relationship with either engagement (r = 0.055, p = 0.647) or motivation (r = 0.151, p = 0.209). However, a strong positive correlation was found between engagement and motivation (r = 0.745, $p < 0.001$), indicating that, as in the immersive VR group, students who were more engaged tended to be more motivated. These results indicate a robust relationship between engagement and motivation in both groups, but no evidence of a direct relationship between either of these factors and learning outcomes.

Discussion

This study was designed to investigate the effects of two different multimedia environments, immersive VR and interactive video, on college students' learning outcomes, motivation, and engagement within the context of the industrial history of a watershed. Findings revealed that students in the immersive VR experience reported significantly higher motivation and engagement. However, although students in the immersive VR group demonstrated knowledge gains, those in the interactive video group achieved significantly higher gains.

Our findings align with prior research indicating that while immersive VR can enhance motivation and engagement, its learning outcomes may not always exceed those of other conventional media (Lawson et al., 2024; Makransky et al., 2021; Parong & Mayer, 2018, 2021). Specifically, they corroborate the conclusion of Makransky et al. (2021) that students gain more declarative knowledge from video-based instruction compared to immersive VR simulations. Similarly, Johnson-Glenberg et al. (2021) found no significant advantage in knowledge retention for immersive VR groups compared to PC-based platforms. Our results also support Parong and Mayer's (2018, 2021) findings, which showed that students demonstrated significantly better knowledge transfer when using an interactive video rather than immersive VR. Additionally, our findings are consistent with the study by Queiroz et al. (2022), where middle school students in the VR condition did not demonstrate better learning outcomes compared to those using video. These results align with the broader literature suggesting that learning in immersive VR is not always more effective than learning with conventional media (Mayer & Bailenson, 2024).

The lower knowledge gains observed in the immersive VR group can be explained by the CTML, which suggests that while immersive VR environments are captivating, they may increase extraneous cognitive load due to the mental demands of navigating a 3D environment, particularly for students using a VR headset for the first time (Makransky, Terkildsen, & Mayer, 2019; Makransky et al., 2021). Furthermore, the fascination elicited by the immersive environment may create excessive positive emotion, which according to CTML, can distract students, leading to reduced generative processing, which is required for meaningful learning (Parong & Mayer, 2021). Observations of students during the immersive VR experience revealed reactions of excitement and amazement; they appeared captivated and deeply engaged by the interactive and vivid virtual environment. The results of the study could be an indication that the effect of added immersion in the VR environment was stronger in terms of increasing extraneous load, and that the added immersion captured students' attention at the expense of cognitive resources required for effective learning. Additionally, the higher knowledge gains observed in the interactive video group may be attributed to its interactive elements, which likely increased the cognitive capacity for generative processing, enabling students to focus on essential content. Furthermore, completing the interactive video on a PC, a device students are generally familiar with, may have further increased generative processing by eliminating the need to adapt to a new interface or technology. This familiarity might have enhanced focused attention and facilitated the generative processing necessary for effective learning.

Despite the lower knowledge gains, the immersive VR group reported significantly higher motivation and engagement compared to their interactive video counterparts. While the results indicate that both groups were motivated and engaged, the immersive VR group demonstrated significantly higher motivation and engagement. These findings are consistent with previous research by Parong and Mayer (2018), Johnson-Glenberg et al. (2021), Wu et al. (2020), and Moreno and Mayer (2002), all of whom found that immersive VR environments tend to enhance motivation and engagement relative to conventional media.

The results of this study revealed a positive correlation between motivation and engagement, but no significant relationship between either of these factors and learning outcomes. This finding is consistent with Al-Khiami et al. (2024), who reported no significant association between motivation and learning outcomes. One explanation for the absence of this relationship in this study may be the increased cognitive load associated with the immersive VR environment.

Participants' unfamiliarity with the immersive VR experience may have contributed to higher extraneous cognitive load, diverting mental resources away from learning. At the same time, the novelty of the immersive VR environment led to enhanced motivation and engagement without necessarily promoting deeper learning. Therefore, while immersive VR is known to enhance motivation and engagement, it does not necessarily lead to improved learning outcomes, a pattern also observed in prior research (Lawson et al., 2024; Makransky et al., 2021; Parong & Mayer, 2018, 2021).

Limitations and future directions

This study had several limitations. First, this study used a convenience sample, which may limit the generalizability of the findings. Second, it did not collect data on students' prior immersive VR experience, which is critical for understanding how familiarity, or lack thereof, might impact cognitive load and the ability to engage effectively in an immersive VR environment. Prior experience could also influence comfort and navigation efficiency, potentially affecting learning outcomes. Additionally, the study did not explore students' perceptions of the design interface and its relationship to learning outcomes. Investigating participants' views on interface elements, such as navigation controls, heads-up displays (HUDs), and interaction feedback, could offer valuable insights into how these features influence learning effectiveness. Furthermore, the absence of qualitative data, such as student interviews, limited the study's ability to explore subjective experiences and perceptions of the instructional media. In addition, this was a short-term implementation study without a follow-up to examine long-term retention. Finally, the reported Cronbach's alpha for the engagement scale was 0.67. While values between 0.60 and 0.70 are acceptable for exploratory research (Hair et al., 2010), this represents moderate reliability. This suggests that future research should utilize or develop instruments with higher internal consistency to ensure more robust measurement of students' engagement.

Future research should address these limitations by employing random sampling to enhance external validity, collecting data on students' prior immersive VR experience and their perceptions of the design interface, and incorporating qualitative methods to gain deeper insights into learners' subjective experiences. Examining the long-term effects of immersive VR on learning outcomes in authentic educational contexts is also essential. Incorporating behavioral metrics, such as the frequency and duration of interactions with different components of the experience, may provide more objective insights into engagement.

Conclusion

This study compared immersive VR and interactive video as educational technologies, finding that while both methods effectively motivate and engage students, immersive VR was significantly more motivating and engaging. However, despite this heightened motivation and engagement, interactive video resulted in better learning outcomes. This aligns with prior research suggesting that immersive experiences, though captivating, can lead to cognitive overload, which may hinder learning (Makransky et al., 2021). This study adds to the literature on immersive VR's impact on learning, emphasizing that while such experiences can be highly motivating and engaging, they do not necessary yield better learning outcomes compared to interactive videos. The findings highlight the importance of selecting appropriate educational technologies based on their specific affordances and the potential to optimize learning outcomes.

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Appendix A. Engagement and motivation survey items

Engagement subscale items for immersive VR and interactive video

The items are written for the VR experience survey. Text in parentheses indicates modifications used for the interactive video experience.

1. I felt excited when I was in the virtual environment (interactive video experience).
2. I felt happy when I was in the virtual environment (interactive video experience).
3. My mind was elsewhere when I was in the (interactive video experience). *
4. I was focused on the virtual environment (interactive video experience) most of the time.
5. I felt bored when I was in the virtual environment (interactive video) experience. *
6. Time went by quickly when I was in the virtual environment (interactive video) experience.

*Item is reverse-coded.

Note: Items were adapted from Chung et al. (2016).

Motivation subscale items for immersive VR and interactive video

Regarding the VR experience

1. I enjoyed learning in the virtual environment (interactive video).
2. I prefer to learn in a virtual environment (using interactive video) even if I have printed materials.
3. I look forward to learning in a virtual environment (from interactive videos).
4. I am satisfied with my experience in the virtual environment (interactive video).
5. I would describe immersive VR (interactive videos) as very interesting.
6. Learning with immersive VR (interactive video) was fun.

Note: Items 1 to 4 were adapted from IMeL (Fırat et al., 2018). Items 5 and 6 were adapted from IMI (Lee et al., 2010; McAuley et al., 1989).

VR: virtual reality; IMeL: Intrinsic Motivation in e-Learning; IMI: Intrinsic Motivation Inventory.