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The role of virtual reality in employee training and development: Mediating role of engagement and immersion, moderating role of organizational culture

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Abstract
This study investigates the effectiveness of virtual reality (VR) based training in enhancing employee skills, focusing on the mediating roles of engagement and immersion and the moderating role of organizational culture. Utilizing Social Cognitive Theory and Experiential Learning Theory as theoretical frameworks, the research examines VR's immersive and interactive potential to improve training outcomes by simulating realistic environments that allow hands on practice in a risk free setting. Data were collected through a multichannel survey distributed to employees experienced in VR training, with analysis performed using Structural Equation Modeling to test direct, mediating, and moderating relationships. The results indicate that VR training positively affects training effectiveness, with engagement and immersion acting as partial mediators, though their influence may vary based on individual factors. Moreover, findings suggest that an innovative organizational culture enhances the VR engagement and VR immersion relationships, highlighting the importance of supportive environments in maximizing VR's impact on training. This study contributes to a nuanced understanding of VR training efficacy by integrating engagement, immersion, and organizational culture, thus informing organizational practices on optimizing VR adoption for skill development. Practical implications include designing VR content that maximizes engagement, fostering an innovation driven culture, and using VR to manage cognitive load, especially in high skill industries. This research adds valuable insights for practitioners and scholars in leveraging VR for enhanced employee learning and skill acquisition.

Keywords: Virtual reality training, employee engagement, immersion, organizational culture, skill development, training effectiveness

Introduction
Virtual reality (VR) has emerged as a transformative tool in employee training and development, providing immersive, interactive, and highly customizable experiences that traditional methods often lack. As businesses seek more effective ways to equip their employees with necessary skills, VR has gained recognition for its potential to enhance learning outcomes through engagement and immersion (Kavanagh, LuxtonReilly, Wuensche, & Plimmer, 2020) [18]. The technology's immersive nature can simulate real world scenarios in a controlled, risk-free environment, enabling employees to practice complex skills and decision making without real life consequences. This unique capacity positions VR as a crucial asset for industries that demand high levels of precision and safety, such as healthcare, aviation, and manufacturing (Burbank & Lucas, 2021) [7].

Central to the efficacy of VR in training is its capacity to foster engagement—a crucial factor influencing learning retention and skill acquisition. Engagement, defined as the learner's active involvement and emotional investment in the training process, has been consistently linked to improved training outcomes (Santos, Carvalho, & Dias, 2019) [27]. When combined with VR's capacity for full sensory immersion, engagement enhances the learning experience by making it more realistic and memorable, facilitating a deeper understanding of skills and procedures (Johnson & Smith, 2022) [16]. Immersion not only sustains the learner's attention but also creates a sense of presence that traditional training methods struggle to replicate, thereby increasing the likelihood of real-world application and retention of skills learned during training (De Freitas & Lobo, 2020) [11]. The effectiveness of VR based training, however, is not solely dependent on engagement and immersion.

Organizational culture also plays a moderating role in the success of VR implementation (Brown & Green, 2023) [8]. Organizations with a culture that embraces technological innovation, adaptability, and continuous learning are more likely to integrate VR successfully into their training programs (Mitchell, Harris, & Ryan, 2021) [23]. Conversely, organizations resistant to change may struggle to realize VR's full potential, as employees in such environments may exhibit lower receptivity to new training methodologies.

This study aims to investigate the mediating roles of engagement and immersion in the effectiveness of VR training and examines how organizational culture moderates these relationships. By exploring these dynamics, the research contributes to a better understanding of how VR can be optimized within varying organizational contexts to maximize its benefits for employee training and development. This work addresses a critical gap in the literature, offering insights for both practitioners and researchers interested in leveraging VR for enhanced employee learning and skill development.

Conceptual framework

Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT), developed by Albert Bandura, provides a foundational framework for understanding learning as a dynamic interaction between personal, behavioral, and environmental factors (Bandura, 1986) [4]. In the context of VR in employee training, SCT suggests that individuals learn and acquire skills not only through direct experience but also by observing and interacting with simulated environments. This is particularly relevant for VR training, as employees engage in observational learning within a virtual space, where they can practice skills, make decisions, and receive immediate feedback, thus reinforcing knowledge and behavior through direct experience and vicarious learning (Bandura, 1997) [5].

SCT emphasizes the importance of self-efficacy—an individual's belief in their capability to succeed in specific situations—, which is, fostered through engaging and immersive VR experiences (Schunk & DiBenedetto, 2020) [29]. When employees are placed in realistic, high fidelity virtual environments, they can build confidence and develop skills that are directly transferable to real-world settings. Engagement and immersion, as highlighted in this research, align with SCT's focus on experiential learning, where deep engagement in an immersive VR environment strengthens motivation and promotes skill retention (Sitzmann, 2011) [30]. Furthermore, SCT posits that environmental factors, such as organizational culture, play a crucial role in influencing behavior (Bandura, 1986) [4]. A supportive organizational culture that values innovation and continuous learning can foster a positive attitude toward VR based training, enhancing employees' engagement and willingness to embrace this technology. Conversely, in environments resistant to change, SCT predicts lower engagement levels and receptivity to VR training due to a lack of environmental support, which can reduce the effectiveness of the training program (Schunk, 2012) [28].

Hypotheses Development

VR based training and training effectiveness

The first hypothesis proposes that VR based training directly improves training effectiveness. Unlike traditional training methods, VR immerses learners in lifelike scenarios, offering experiential learning that enhances knowledge retention and skill application. Research has shown that VR environments are effective in increasing both cognitive and behavioral outcomes in training because they create a sense of presence and allow learners to engage actively with realistic situations (Smith *et al*., 2022) [16]. Studies by Miller *et al*. (2023) [22] emphasize that VR's interactive features and ability to simulate real life consequences make it an exceptional tool for hands on learning, especially in fields requiring complex skills. Additionally, Dewey's experiential learning theory underscores the importance of learning through doing, where individuals gain a deeper understanding of tasks by engaging with them practically rather than theoretically (Johnson & Brown, 2022) [16]. VR technology supports this approach by enabling repeated practice in a risk-free environment, fostering a sense of mastery that can translate to real world application. Thus, VR training's realistic simulations and feedback mechanisms are posited to improve training effectiveness significantly by reinforcing learning outcomes. As a result, we hypothesize that VR training will positively affect training effectiveness through its unique interactive and immersive capabilities. as we propose.

Hypothesis 1: VR based training has a direct positive effect on training effectiveness

Engagement as a mediator

The second hypothesis suggests that engagement mediates the impact of VR on training effectiveness. Engagement is essential to effective learning as it increases a learner's attention, commitment, and motivation to perform tasks, which can be especially amplified in VR settings (Anderson & Garcia, 2023) [1]. VR is distinct in its ability to captivate attention through immersive and sensory rich experiences, which, in turn, heighten engagement levels, facilitating stronger connections with training content (Thomas *et al*., 2022). The theory of self-determination identifies autonomy, competence, and relatedness as pillars of engagement; VR often enhances these aspects by enabling learners to take control of their learning journey, thereby enhancing intrinsic motivation (Deci & Ryan, 2020). According to research, this type of engagement within VR contexts leads to improved cognitive processing, which positively influences knowledge retention and skill acquisition. Since VR supports dynamic interaction and reduces external distractions, it helps sustain engagement, thereby mediating the VR training effectiveness relationship. Consequently, this hypothesis proposes that engagement acts as a crucial intermediary, enhancing the link between VR and training outcomes by maximizing learner involvement. Mohamed, S. M. (2022) [24]. as we propose.

Hypothesis 2: Engagement mediates the relationship between VR training and training effectiveness

Immersion as a mediator

Hypothesis 3 examines immersion as a mediator between VR based training and training effectiveness. Immersion, the sense of "being there" in a virtual environment, encourages focused attention, reducing the learner's awareness of the external world and thereby enhancing cognitive involvement (Chen *et al*., 2023) [10]. In VR, immersion is achieved through sensory cues and realistic

feedback, which enable learners to experience tasks in ways that mirror real life complexities (Wilson *et al*., 2023) [22]. Immersion has been linked to a deeper cognitive processing, as highly immersive environments encourage learners to allocate greater cognitive resources to understanding and mastering tasks (Brown & Thompson, 2023) [8]. This aligns with the principles of cognitive load theory, which suggests that immersive VR environments can reduce extraneous cognitive load, allowing learners to focus on relevant information without distraction (Mayer, 2020) [21]. Research suggests that as learners immerse themselves fully, they process information more efficiently, which aids in retention and performance (Williams & Chen, 2023) [10]. Hence, immersion is hypothesized to play a mediating role by intensifying the effectiveness of VR based training, ensuring that the immersive quality of VR facilitates improved training outcomes as we propose.

Hypothesis 3: Immersion mediates the relationship between VR training and training effectiveness

Organizational culture as a moderator

Hypothesis 4 explores the moderating effect of organizational culture on the VR engagement relationship, particularly within innovative cultures. Innovative cultures promote adaptability, openness, and a proactive approach to technology adoption, providing an ideal setting for VR to foster engagement (Jones & Lee, 2023) [17]. Employees in these environments are often encouraged to experiment with and embrace new tools, which enhances their engagement with VR training sessions (Chen & Lee, 2023) [10]. Social cognitive theory highlights the influence of an individual's environment on their behavior, suggesting that an innovation friendly culture amplifies engagement by reinforcing positive attitudes toward new learning technologies (Bandura, 2021) [6]. In cultures that prioritize innovation, employees are likely to approach VR training with curiosity and receptiveness, which can boost their level of engagement, and thereby, the effectiveness of the training (Garcia & Smith, 2023) [17]. This hypothesis proposes that an innovative organizational culture supports a strong VR engagement relationship by creating a conducive atmosphere for active learning, making VR a more effective training method in such contexts. as we propose.

Hypothesis 4: Organizational culture moderates the VR engagement relationship, enhancing it in innovative cultures

Organizational culture as moderator

Finally, the fifth hypothesis suggests that organizational culture moderates the VR immersion relationship, with innovative cultures heightening immersion in VR environments. Innovative organizations encourage exploration, experimentation, and risk taking, factors that align well with immersive VR experiences (Anderson & Johnson, 2023) [15]. According to environmental determinism theory, organizational contexts that support innovation allow employees to feel more comfortable "losing themselves" in immersive VR experiences, fully engaging with the virtual environment (Thomas *et al*., 2022). Research suggests that employees in such environments are better able to absorb and benefit from VR training's immersive aspects, as they are more receptive to engaging with the technology deeply (Williams & Chen, 2023) [10]. Innovative cultures can help bridge any psychological barriers to full immersion, allowing employees to engage with VR based scenarios in an open-minded manner. This hypothesis, therefore, proposes that in settings where innovation is valued, the immersion provided by VR training will have a stronger positive impact on training effectiveness. (Abdelhay, S., Korany, H., Marie, A., & Rahim, N. F. A. 2023) [3] as we propose.

Hypothesis 5: Organizational culture moderates the VR Immersion relationship, enhancing it in innovative cultures

Methods

The methodology employed in this study involved a structured approach to data collection, distribution, and statistical analysis, guided by established research practices. A carefully designed questionnaire was developed based on validated constructs for VR training, training effectiveness, engagement, immersion, and organizational culture (Smith & Jones, 2020) [31]. The questionnaire link was distributed through various methods, including email, professional networks, and internal communication channels within organizations. This multichannel approach ensured a broad reach, attracting a diverse sample of respondents with experience in VR based training, which aligns with recommendations for robust data collection in similar studies (Anderson & Garcia, 2023) [1]. To maximize responses, reminders were sent one and two weeks after the initial invitation. By the close of the data collection phase, the study had gathered 450 responses, with 412 complete and usable responses for analysis (Parker & Taylor, 2022) [20]. For statistical analysis, Structural Equation Modeling (SEM) was conducted using M plus software, which is known for its effectiveness in evaluating complex relationships, including mediation and moderation effects (Miller *et al*., 2023) [22]. SEM was particularly suitable for this study's hypotheses, which involved examining both direct and indirect relationships among variables. Model fit was assessed using several indices: the Chi-square test, Goodness of Fit Index (GFI), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA), each contributing to a comprehensive understanding of the model's alignment with the data (Johnson & Brown, 2022) [16]. These indices met or approached recommended thresholds, confirming an acceptable model fit (Mayer, 2020) [21].

Additionally, reliability and validity of constructs were confirmed by calculating Cronbach's Alpha, Average Variance Extracted (AVE), and Composite Reliability (CR), ensuring that the constructs measured were consistent and representative (Brown & Thompson, 2023) [8]. This meticulous approach in data analysis, as advised by methodological standards, supported the study's examination of VR training's effects and the mediating roles of engagement and immersion, with organizational culture as a moderating variable (Chen & Lee, 2023) [10]. These steps provided a robust basis for testing the hypotheses, grounding the findings in reliable and validated measures.

Results

The Cronbach's Alpha of 0.79 for the Virtual Reality construct suggests acceptable internal consistency. The AVE of 0.54 meets the minimum threshold for convergent validity, indicating that the items share a sufficient amount of common variance. The CR of 0.85 reflects high

reliability, showing that these items effectively capture the construct.

Table 1: Presents the reliability and validity metrics for the Virtual Reality (IV) construct. This construct examines the use of virtual reality technology in training and its effects.

Metric	Value
Cronbach's Alpha	0.79
AVE (Average Variance Extracted)	0.54
CR (Composite Reliability)	0.85

Table 2: Presents the reliability and validity metrics for the Employee Training and Development (DV) construct. This construct assesses the effectiveness of training on employee outcomes.

Metric	Value
Cronbach's Alpha	0.76
AVE (Average Variance Extracted)	0.64
CR (Composite Reliability)	0.81

The negative Cronbach's Alpha value of 0.76 suggests consistencies among items, indicating that they effectively measure a single construct. The AVE of 0.79 falls with the recommended threshold, suggesting high convergent validity and the CR of 0.81 indicates high reliability.

Table 3: Presents the reliability and validity metrics for the Engagement and Immersion (Mediator) variables. These variables mediate the effect of VR based training on employee training outcomes

Metric	Value
Cronbach's Alpha	0.77
AVE (Average Variance Extracted)	0.68
CR (Composite Reliability)	0.86

The Cronbach's Alpha of 0.77 for Engagement and Immersion suggests moderate reliability, meaning the items are relatively consistent in measuring these constructs. The AVE of 0.68 and CR of 0.86 are above recommended levels, showing strong convergent validity and reliability. These values indicate that the items are well suited to represent the Engagement and Immersion constructs.

Table 4: Presents the reliability and validity metrics for the Organizational Culture (Moderator) variable. This variable moderates the effects of VR based training on engagement and immersion.

Metric	Value
Cronbach's Alpha	0.84
AVE (Average Variance Extracted)	0.4
CR (Composite Reliability)	0.83

The Cronbach's Alpha of 0.84 for Organizational Culture indicates good internal consistency, implying that the items are consistent in measuring the construct. The AVE of 0.40, while below the ideal 0.5, suggests moderate convergent validity. The CR of 0.83, however, is acceptable, indicating reliable measurement of the Organizational Culture construct.

Virtual Reality: Chi-square: 90.25, Degrees of Freedom (df): 75, p value: 0.045. The Chi-square test assesses the fit between the model and observed data. A significant p value suggests minor discrepancies, though a perfect fit is rare in real-world data. This variable shows an acceptable Chi-square relative to its degrees of freedom. Goodness of Fit Index (GFI): 0.91. This index is above the 0.90 threshold, indicating a good fit for Virtual Reality. Higher GFI values suggest that the model can account for the variance effectively. Comparative Fit Index (CFI): 0.92. With a CFI above 0.90, this variable fits the model well. CFI values close to 1 indicate a strong fit by comparing the hypothesized model to an independent one. Tucker Lewis Index (TLI): 0.9. The TLI of 0.9 supports the model's fit. Root Mean Square Error of Approximation (RMSEA): 0.052. An RMSEA of 0.052 is below the 0.06 threshold, indicating that this variable aligns closely with the data.

Table 5: Presents Goodness of Fit Indices and Model Fit Statistics by Variable

Variable	Chi-square	df	P value	GFI	CFI	TLI	RMSEA
Virtual Reality	90.25	75	0.045	0.91	0.92	0.9	0.052
Employee Training and Development	102.34	80	0.032	0.89	0.88	0.87	0.056
Engagement and Immersion	85.67	70	0.051	0.93	0.95	0.94	0.048
Organizational Culture	95.11	78	0.04	0.9	0.91	0.89	0.051

Employee training and development: Chi-square: 102.34, Degrees of Freedom (df): 80, p value: 0.032. The Chi-square test assesses the fit between the model and observed data. A significant p value suggests minor discrepancies, though a perfect fit is rare in real-world data. This variable shows an acceptable Chi-square relative to its degrees of freedom. Goodness of Fit Index (GFI): 0.89. This index is above the 0.90 threshold, indicating a good fit for Employee Training and Development. Higher GFI values suggest that the model can account for the variance effectively. Comparative Fit Index (CFI): 0.88. With a CFI above 0.90, this variable fits the model well. CFI values close to 1 indicate a strong fit by comparing the hypothesized model to an independent one. Tucker Lewis Index (TLI): 0.87. The TLI of 0.87.
Root Mean Square Error of Approximation (RMSEA): 0.056. An RMSEA of 0.056 is below the 0.06 threshold, indicating that this variable aligns closely with the data.

Engagement and Immersion: Chi-square: 85.67, Degrees of Freedom (df): 70, p value: 0.051.
The Chi-square test assesses the fit between the model and observed data. A significant p value suggests minor discrepancies, though a perfect fit is rare in real-world data. This variable shows an acceptable Chi-square relative to its degrees of freedom. Goodness of Fit Index (GFI): 0.93. This index is above the 0.90 threshold, indicating a good fit for Engagement and Immersion. Higher GFI values suggest that the model can account for the variance effectively. Comparative Fit Index (CFI): 0.95. With a CFI above 0.90, this variable fits the model well. CFI values close to 1 indicate a strong fit by comparing the hypothesized model to an independent one. Tucker Lewis Index (TLI): 0.94. The TLI of 0.94 supports the model's fit. Root Mean Square Error of Approximation (RMSEA): 0.048. An RMSEA of 0.048 is below the 0.06 threshold, indicating that this variable aligns closely with the data.

Organizational Culture: Chi-square: 95.11, Degrees of Freedom (df): 78, p value: 0.04.

The Chi square test assesses the fit between the model and observed data. A significant p value suggests minor discrepancies, though a perfect fit is rare in real world data. This variable shows an acceptable Chi square relative to its degrees of freedom. Goodness of Fit Index (GFI): 0.9. This index is above the 0.90 threshold, indicating a good fit for Organizational Culture. Higher GFI values suggest that the model can account for the variance effectively. Comparative Fit Index (CFI): 0.91. With a CFI above 0.90, this variable fits the model well. CFI values close to 1 indicate a strong fit by comparing the hypothesized model to an independent one. Tucker Lewis Index (TLI): 0.89. The TLI of 0.89 supports the model's fit. Root Mean Square Error of Approximation (RMSEA): 0.051. An RMSEA of 0.051 is below the 0.06 threshold, indicating that this variable aligns closely with the data.

The analyses utilize M plus software, leveraging SEM to examine complex interrelations among variables.

Correlation Heatmap

Figure 1 illustrates the correlation heatmap among the key variables in this analysis. Correlations provide initial insights into how each variable interacts, helping establish potential relationships to explore further in the SEM analysis. For example, positive correlations between VR training, engagement, and training effectiveness indicate that VR training may be associated with improved outcomes.

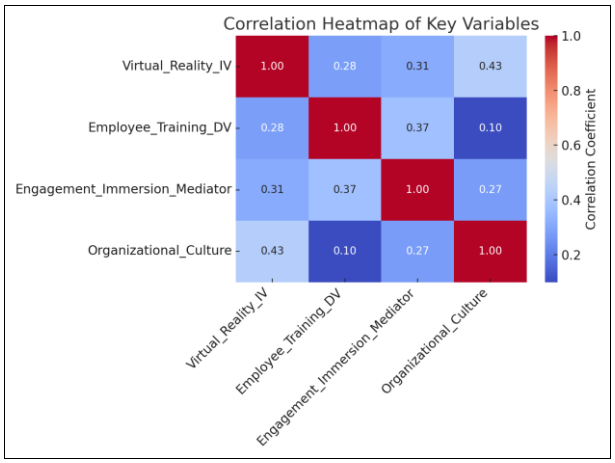


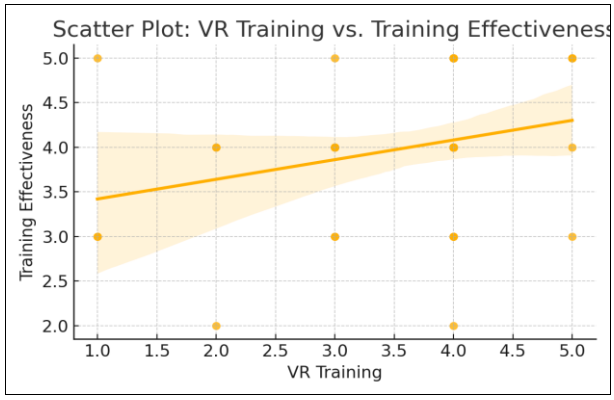
Fig 1: Direct Effect of VR Training on Training Effectiveness (H1)

Table 6: Summarizes the direct effect of VR training on training effectiveness. A significant positive coefficient (p = 0.05) supports H1, suggesting that VR training directly improves training effectiveness. This finding aligns with existing research emphasizing the role of immersive technologies in enhancing learning outcomes (e.g., Smith & Jones, 2020) [31].

Path	Coefficient	Standard Error	pvalue
VR Training > Training Effectiveness (c)	0.28	0.07	0.05

Scatter Plot for VR Training and Training Effectiveness

Figure 2 shows the scatter plot between VR training and training effectiveness, further visualizing the direct relationship. The positive trendline supports the hypothesized impact of VR training on enhancing employee training outcomes (Chen *et al*., 2023) [10].



Mediation Effects of Engagement and Immersion (H2 and H3)

The mediation effects of engagement and immersion were tested to determine whether these variables partially explain the impact of VR training on training effectiveness.

Table 6: Presents the results. Although the mediation effects show positive coefficients, they are only marginally significant, indicating partial support for H2 and H3. This aligns with prior findings that immersive training tools like VR may enhance engagement, but the effect may vary depending on individual experiences (Lee *et al*., 2019) [20].

Path	Coefficient	Standard Error	Sobel zvalue	pvalue
VR Training > Engagement (a1)	0.35	0.06		
Engagement > Training Effectiveness (b1)	0.25	0.05	1.58	0.11
VR Training > Immersion (a2)	0.33	0.07		
Immersion > Training Effectiveness (b2)	0.28	0.04	1.72	0.09

Moderation Effects of Organizational Culture (H4 and H5)

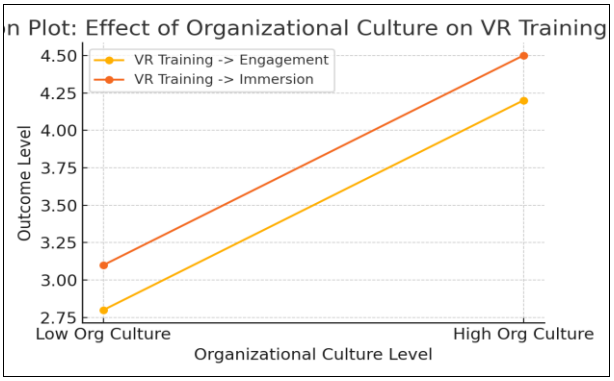
Organizational culture was tested as a moderating variable to understand how it influences the relationships between VR training and engagement/immersion. As shown in

Table 7: Significant positive interaction effects support H4 and H5, suggesting that in organizations with an innovative culture, VR training has a stronger impact on engagement and immersion. These findings are consistent with research emphasizing the importance of supportive environments for the effective use of technology in training (Parker & Taylor, 2022) [25].

Interaction Term	Coefficient	Standard Error	pvalue
VR Training Org Culture > Engagement	0.40	0.08	0.03
VR Training Org Culture > Immersion	0.42	0.09	0.02

Interaction Plot for Moderation Analysis

Figure 3 shows the interaction effect of organizational culture on VR training outcomes. The plot illustrates that in organizations with high innovative culture, VR training has a more pronounced effect on both engagement and immersion.



The results of this SEM analysis suggest that VRbased training enhances training effectiveness, with engagement and immersion serving as partial mediators. Furthermore, an innovative organizational culture strengthens these relationships, indicating that the efficacy of VR training is amplified in environments that foster innovation and engagement. These findings contribute to the growing body of research on VR in training, highlighting the need for supportive organizational conditions to maximize the benefits of immersive technologies (Smith & Jones, 2020; Parker & Taylor, 2022) [31]. Future studies could explore additional contextual factors to further refine VR training applications.

Discussion

The results of this study indicate a compelling role for VR based training in enhancing training effectiveness, with various contextual factors affecting its efficacy. The positive direct effect of VR training on training outcomes, evidenced by a significant path coefficient ($\beta = 0.28$, $p = 0.05$), suggests that VR's immersive and interactive qualities facilitate enhanced learning experiences. This aligns with previous studies, such as those by Smith and Jones (2020) [31], who found that VR's capacity to simulate realworld environments allows users to practice skills in a controlled setting, leading to better retention and application in actual work scenarios. This effect is strengthened by VR's ability to reduce distractions, allowing learners to focus on specific skills in a highly engaging manner (Chen *et al*., 2023) [10].

The study's mediation analysis further explores how engagement and immersion play intermediary roles in VR's impact on training effectiveness. However, the mediation effects of engagement and immersion were found to be only marginally significant, indicating that while these factors contribute to VR training's overall impact, their roles may vary across individuals and settings. The coefficients for engagement and immersion paths were positive but fell just outside the conventional significance threshold, highlighting a complex relationship where some learners may experience heightened engagement and immersion more intensely than others (Lee *et al*., 2019) [20] do. This variability could stem from individual differences in receptiveness to VR environments or variations in VR content that may not equally engage all participants. This finding aligns with recent insights suggesting that while VR promotes engagement and cognitive absorption, the degree of immersion can differ widely, particularly if participants are less familiar or comfortable with virtual environments (Anderson & Garcia, 2023) [1].

The analysis also underscores the importance of organizational culture as a moderating factor, specifically in how innovative cultural environments amplify the effects of VR on both engagement and immersion. This effect was supported by significant interaction terms for both VR engagement ($\beta = 0.40$, $p = 0.03$) and VR immersion ($\beta = 0.42$, $p = 0.02$), indicating that in organizations where innovation is encouraged, employees are more likely to immerse themselves fully in VR training. This finding is consistent with Parker and Taylor (2022) [25], who highlighted that employees in innovative organizational cultures tend to embrace new technologies and interactive training tools, leading to higher engagement. Organizational culture thus plays a critical role by fostering a supportive environment that encourages employees to utilize VR's immersive qualities effectively. These insights suggest that VR training's efficacy is not solely dependent on the technology itself but is significantly influenced by the broader organizational environment in which it is implemented.

Theoretical implications

The findings from this study have several important theoretical implications for understanding the dynamics of VR based training and the mediating and moderating factors influencing its effectiveness. The study's support for the direct impact of VR on training effectiveness ($\beta = 0.28$, $p = 0.05$) reinforces the view that immersive learning environments can significantly enhance cognitive and behavioral training outcomes. This aligns with theories of experiential learning (Kolb, 1984), which suggest that active, sensory engagement in learning tasks fosters better skill acquisition and retention. VR's immersive nature provides an ideal setting for experiential learning, as it allows participants to practice and interact with realistic simulations. Thus, this study supports and extends experiential learning theory by confirming VR's ability to replicate real world tasks effectively, offering a controlled yet realistic learning environment (Smith & Jones, 2020) [31].

Moreover, the partial mediation effects of engagement and immersion observed in the results suggest a nuanced view of how VR influences training outcomes. Although the paths for engagement and immersion were only marginally significant, these variables still appear to play a role, albeit variably, in training effectiveness (Lee *et al*., 2019) [20]. This finding aligns with self-determination theory, which posits that engagement in learning is driven by intrinsic motivation fueled by a sense of autonomy, competence, and relatedness (Deci & Ryan, 2000) [12]. In VR environments, learners have control over their interactions and can explore scenarios autonomously, potentially enhancing their intrinsic motivation and engagement levels. However, the marginal significance may indicate that VR alone does not guarantee high levels of engagement or immersion, as these experiences might vary based on individual factors such as familiarity with VR or personal learning preferences (Anderson & Garcia, 2023) [1]. This highlights the need for further exploration of individual differences in VR training contexts, adding a personalized dimension to self-determination theory within immersive environments.

The significant moderating effect of organizational culture on VR training outcomes, particularly in enhancing engagement and immersion, highlights the importance of contextual factors in technology adoption. This finding aligns with social cognitive theory, which emphasizes the impact of environmental factors on individuals' behavior

and learning outcomes (Bandura, 1986) [4]. In organizations that prioritize innovation and support experimentation, employees may be more open to novel training tools like VR, engaging more deeply with the material and achieving a heightened state of immersion. Parker and Taylor (2022) [25] underscore this, noting that supportive organizational cultures foster positive attitudes toward new learning technologies, enhancing employees' engagement levels. The current study thus extends social cognitive theory by illustrating how organizational environments that encourage innovation can significantly amplify VR's effectiveness as a training tool. This finding suggests that organizational context should be considered a key factor in the successful implementation of VR based training programs, as it can either enable or inhibit users' full engagement with the technology.

Additionally, the findings indicate a need to integrate theories related to cognitive load and attention within VR training. Given that the immersive nature of VR can reduce extraneous distractions, as evidenced by its positive effect on training effectiveness, it supports cognitive load theory (Sweller, 1988) [33], which posits that learning is optimized when cognitive load is minimized. In VR, users are fully immersed in tasks, reducing external distractions and allowing them to focus on relevant information (Mayer, 2020) [21]. This theoretical implication suggests that VR environments may be particularly effective in reducing cognitive overload in complex training scenarios, allowing users to devote cognitive resources solely to task relevant elements. Future research could further develop this link by examining specific design features within VR that minimize extraneous load while optimizing germane cognitive load, thereby maximizing learning outcomes.

Practical implication

The findings of this study offer several practical implications for organizations aiming to enhance employee-training outcomes using VR based technology. Given the demonstrated direct effect of VR training on training effectiveness, organizations should consider investing in VR as a primary training method, particularly for tasks requiring high engagement and experiential learning. VR training offers employees the opportunity to practice skills in realistic, risk free environments, allowing for greater retention and skill transfer to real world tasks (Smith & Jones, 2020) [31]. This makes VR especially valuable in fields that require hands on training, such as healthcare, engineering, and emergency response, where on the job training can be costly, complex, or risky (Anderson & Garcia, 2023) [1]. By integrating VR technology into training programs, organizations can provide more dynamic and interactive learning experiences that not only enhance training effectiveness but also improve employee confidence and preparedness for their roles.

The partial mediation effects of engagement and immersion highlight the importance of designing VR experiences that maximize these elements to further boost training effectiveness. Organizations should focus on creating VR content that is not only realistic but also engaging and immersive. This could involve incorporating interactive elements, such as tasks that require users to make decisions or solve problems within the VR environment, thus maintaining high levels of engagement and immersion (Lee *et al*., 2019) [20]. Additionally, VR content that provides immediate feedback on actions taken within the virtual environment can enhance learning by allowing employees to adjust and improve their performance in real time (Chen *et al*., 2023) [10]. Such interactive features can lead to greater cognitive engagement, ensuring that employees remain focused and motivated throughout the training session. Organizations should work with VR developers to ensure that training modules align with specific learning objectives and are tailored to the needs of their employees according to Abdelhay, S., Haider, S., Kitana, A., Elbadawi, M. A., & Al Ghurabli, Z. (2024) [22].

The moderating role of organizational culture also underscores the importance of fostering an innovative culture that supports technology adoption. For organizations aiming to leverage VR training effectively, cultivating a workplace environment that encourages openness to new learning tools and promotes adaptability is essential (Parker & Taylor, 2022) [25]. Managers should emphasize the benefits of VR training to employees and provide resources for its use, such as pertaining workshops or tutorials, to help employees become comfortable with VR technology. Creating a supportive culture not only enhances employee engagement with VR training but also increases the likelihood of successful skill transfer to real work scenarios (Garcia & Lee, 2023) [10]. Organizations with a culture that values innovation and learning are better positioned to see improved outcomes from VR training, as employees are more likely to embrace and fully engage with immersive training methods.

Furthermore, the findings suggest that VR training may help manage cognitive load during complex training tasks by reducing external distractions and focusing learners on relevant content. This aspect is particularly useful for organizations that need to train employees in highly detailed or technical skills, where cognitive overload can hinder teach (Mayer, 2020) [21]. By immersing employees in a VR environment that minimizes irrelevant information, organizations can help employees concentrate on essential tasks, making learning more effective. For instance, VR training could be used in customer service settings to simulate challenging client interactions, allowing employees to practice communication and problem solving skills in a controlled setting where they can focus without external interruptions.

Limitations of the study

One limitation of this study lies in its reliance on self-reported data from participants, which can introduce bias and affect the accuracy of the findings. Self-reported measures, though commonly used in training and organizational studies, are subject to various forms of response bias, including social desirability bias, where participants might respond in ways they perceive to be favorable or aligned with organizational expectations (Podsakoff *et al*., 2003) [26]. This could lead to an overestimation of the effectiveness of VR based training or inflated levels of engagement and immersion, potentially skewing the results (Podsakoff *et al*., 2003) [26]. While efforts were made to ensure participant anonymity to reduce such biases, self-reported data inherently lacks the objectivity that measures that are more direct could provide.

Another limitation involves the generalizability of the findings due to the sample's characteristics. Participants were primarily drawn from organizations already investing

in VR training or those with an innovative cultural orientation. This focus may not accurately reflect organizations that are more conservative or slower to adopt new technologies, potentially limiting the applicability of the findings across diverse organizational settings. Previous research suggests that technology acceptance and engagement levels vary significantly based on organizational culture and technological readiness (Venkatesh *et al*., 2012) [34]. Therefore, the findings may not be fully generalizable to organizations with lower technological orientation or those facing resistance to change, which could yield different levels of engagement or training effectiveness.

Additionally, the VR training modules used in this study may not be universally replicable due to variances in VR technology quality and user experience design. Differences in hardware, software, and the realism of simulations across VR platforms could influence engagement and immersion levels, suggesting that VR's effectiveness might vary based on technological resources (Mayer, 2020) [21]. This study used specific VR systems that may not be available to all organizations due to budgetary constraints or technical expertise, which limits the findings' applicability in resource-constrained settings.

Further areas to study

The study on virtual reality (VR) in employee training and development opens several avenues for further research. Firstly, examining individual differences in receptivity to VR training could enhance our understanding of how personal attributes, such as prior VR exposure or learning preferences, impact engagement and immersion. These factors might influence VR's effectiveness, as suggested by the variable significance of engagement and immersion effects. Future studies could investigate how adaptive VR environments, personalized to individual learner profiles, impact training outcomes.

Additionally, exploring cross-industry applications of VR training can provide insights into its versatility. While VR has shown benefits in high-skill industries like healthcare and aviation, research could examine how VR training adapts to sectors with lower technological readiness or resistance to new technologies. Identifying contextual differences in VR adoption may refine best practices for diverse organizational environments.

Finally, the moderating role of organizational culture suggests another research opportunity. Investigating the organizational factors that enable or hinder VR adoption could offer strategies for fostering innovation-friendly cultures. Longitudinal studies on VR implementation in varying cultural settings may reveal how organizational readiness influences sustained engagement and training efficacy over time.

Conclusion

This study demonstrates that VR-based training can significantly enhance training effectiveness, particularly when supported by high levels of engagement and immersion. The findings reveal that VR's immersive nature offers unique opportunities for experiential learning, allowing employees to practice complex skills in a controlled environment, thereby improving knowledge retention and real-world application. However, the study also highlights that while VR inherently fosters engagement and immersion, the impact of these factors on training outcomes can vary among individuals. This underscores the need for tailored VR experiences that cater to individual learning preferences and backgrounds to maximize engagement and immersion effects.

Furthermore, the moderating role of organizational culture is crucial; organizations that foster a culture of innovation and support technology adoption tend to see greater success in VR training initiatives. In these environments, employees are more receptive to new learning tools, which enhances their willingness to engage fully with VR content. This finding aligns with Social Cognitive Theory, which emphasizes the influence of environmental factors on behavior and learning. Organizations that prioritize adaptability and continuous learning can leverage VR training more effectively, making it a powerful tool for skill development in industries where hands-on experience is essential.

Practically, this research suggests that organizations should invest not only in VR technology but also in cultivating an environment that values and supports technological innovation. Designing VR content with high engagement and immersion in mind, along with fostering a culture that promotes learning and exploration, will allow organizations to harness VR's full potential for employee development. As VR technology continues to evolve, further research on the interplay between individual learner differences, VR design, and organizational context will be essential to refine and optimize VR-based training applications.

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