Strategizing VR Integration in Business and Education: Extending the Technology Acceptance Model through Project Management Perspectives

Li Tao[1,†], Serhii Dolhopolov[1,†] and Tetyana Honcharenko[1,†]

[1] *Kyiv National University of Construction and Architecture, 31, Air Force Avenue, Kyiv, 03037, Ukraine*

Abstract

The advent of Virtual Reality (VR) technology has sparked a significant transformation in both business and education sectors by introducing immersive experiences that redefine traditional practices. This research delves into the impact of VR, with a particular focus on its acceptance and strategic implications across various sectors. By enhancing the Technology Acceptance Model (TAM) to incorporate VR-specific factors such as perceived usefulness, ease of use, enjoyment, and external variables like age and curiosity, this study rigorously examines the determinants of VR hardware acceptance. Structural Equation Modeling (SEM) is employed to validate the extended TAM, offering deep insights into both consumer and enterprise adoption patterns. The analysis further explores the VR value chain, emphasizing its pivotal role in enhancing VR experiences and detailing strategic frameworks for VR's development to boost product development and operational efficiency. The findings highlight a shift towards software-driven revenue, the expanding utilization of VR in training and design, and its significant contributions to academic research. From a project management perspective, the study underscores the necessity of integrating VR into business and educational strategies to maximize benefits. It advocates for project managers to consider VR's potential to enhance project outcomes through improved training, design precision, and operational efficiencies. By embracing ongoing innovation in the evolving VR landscape, stakeholders can leverage VR as a transformative tool in their strategic and project management practices, ensuring that they stay at the forefront of technological advancement and maintain competitive advantages.

Keywords

Project Management, Virtual Reality (VR), Technology Acceptance Model (TAM), VR Hardware Acceptance

1. Introduction

Virtual Reality (VR) has evolved from an innovative concept to a principal catalyst for technological advancement, impacting diverse domains including entertainment, education, and healthcare. This evolution is fueled by significant advancements in hardware

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† These authors contributed equally.

li_tao@knuba.edu.ua (L. Tao) dolhopolov@icloud.com (S. Dolhopolov); goncharenko.ta@knuba.edu.ua (T. Honcharenko)

0000-0001-8104-5208 (L. Tao); 0000-0001-9418-0943 (S. Dolhopolov); 0000-0003-2577-6916 (T. Honcharenko)

and software, making VR increasingly accessible and adaptable. Pioneering insights from J. Steuer [1] on telepresence and F. P. Brooks [2] on immersive experiences have underscored VR's potential to redefine our interaction with digital spaces. Subsequent studies by L. P. Berg and J. M. Vance [3], S. C. Jang and Y. Namkung [4], and M. V. Rosing et al. [5] have further delineated VR's expansive capabilities and its application across varied fields.

In the business sector, VR emerges as a dynamic tool, enhancing operational efficiency, reimagining product design, and fortifying customer engagement strategies. It facilitates advanced data visualization, environmental simulations, and immersive training environments that streamline project management processes, improve cost-effectiveness, and optimize project outcomes. Similarly, in the realm of education, VR introduces a shift from conventional teaching methods to interactive, experiential learning processes that substantially improve understanding and retention of complex materials, as evidenced by the research of M. Gall and S. Rinderle-Ma [6], B. St-Aubin et al. [7], and C. Ma et al. [8].

This study is propelled by several objectives:

1) To analyze the current landscape of VR technology and its diverse applications within business and educational settings, drawing on the foundational contributions of F. P. Brooks [2], J. Steuer [1], and others.
2) To investigate the factors influencing the acceptance and integration of VR technology using an extended Technology Acceptance Model (VR-HAM) informed by the works of F. D. Davis [9], V. Venkatesh et al. [10], and others.
3) To assess the strategic implications of VR adoption within business and educational frameworks, employing project management principles to enhance the implementation of F. D. Davis [9] and extending them through the insights of N. Christoff et al. [11], Ajzen [12], and others.
4) To offer actionable insights for the effective integration of VR technology across various sectors, aiming to fully leverage its potential.

The research leverages a modified Technology Acceptance Model (TAM), augmented to include VR-specific elements such as perceived enjoyment and external influences like age, curiosity, past usage, and cost considerations. This enriched model, inspired by the seminal work of F. D. Davis et al. [9] and extended by V. Venkatesh and F. D. Davis [10], H. E. Sumbmul et al. [13], and others, provides a multifaceted framework for analyzing the adoption and utilization of VR technology, emphasizing project management strategies that ensure the successful deployment and sustained use of VR initiatives.

2. Main research

2.1. Technology Acceptance Models

The Technology Acceptance Model (TAM), initially conceptualized by F. D. Davis [9], has served as a cornerstone in the study of technology adoption. Central to TAM are two primary constructs: perceived usefulness (PU) and perceived ease of use (PEOU). These constructs form the foundation for understanding the adoption and extensive usage of technologies, suggesting that the easier and more beneficial a technology is perceived to be, the more likely it is to be embraced.

Perceived Usefulness in this context is the extent to which an individual believes that using a specific technology will enhance their job performance or quality of life. Perceived Ease of Use, on the other hand, refers to the degree to which a person expects that using the technology will be effortless. These principles have been applied broadly across various technological fields, from information systems to consumer electronics, showcasing the model's adaptability and resilience.

In the realm of Virtual Reality (VR), researchers, including V. Venkatesh [10], have adapted TAM to reflect the unique characteristics of VR technologies. This adaptation includes additional constructs tailored to VR's immersive and experiential nature, which go beyond traditional usability and utility. Perceived Enjoyment, which gauges the intrinsic enjoyment derived from using technology, becomes particularly relevant in VR due to its potential for entertainment and rich, experiential interactions.

Furthermore, external variables such as age, curiosity, past use, and price willingness have been woven into the VR-specific TAM framework. These elements offer a deeper insight into the diverse factors influencing VR technology acceptance:

- Age examines how demographic factors shape technology adoption rates.
- Curiosity assesses an individual's eagerness to explore new technologies, which can drive the adoption of innovative systems like VR.
- Past Use considers the impact of previous experiences with VR or related technologies on current perceptions and adoption choices.
- Price Willingness measures the economic considerations that influence decisions to adopt VR technologies.

The enhanced TAM for VR, enriched by the contributions of H. E. Sumbmul et al. [13] and V. Venkatesh et al. [10], strategically captures the distinctive attributes of VR and its impact on user acceptance. This refined model provides a comprehensive framework for understanding VR adoption dynamics, filling the void left by traditional TAM applications and better aligning with VR's specific characteristics.

The expanded TAM model can serve as a pivotal tool in project management, particularly in projects involving the deployment of VR technologies. Project managers can utilize insights from this model to design adoption strategies that consider both the technological and human factors influencing the successful integration of VR into business processes and educational settings. Understanding these factors aids in the effective planning, execution, and evaluation of VR projects, ensuring that such initiatives meet their intended goals and are embraced by users.

Figure 1 illustrates the initial model of technology acceptance as proposed by F. D. Davis, highlighting how perceptions of utility and ease influence technology adoption decisions. However, TAM's simplicity limits its applicability in contexts where user choices are voluntary, such as with VR hardware [14–17].

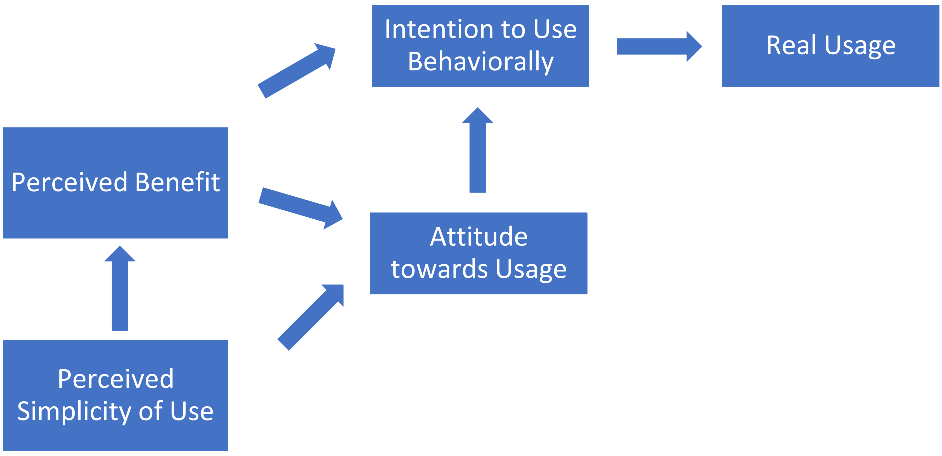

Figure 1: The initial model of technology acceptance by F. D. Davis.

2.2. Applications of VR in Business and Education

The adoption of Virtual Reality (VR) technology in business and education sectors highlights its broad and transformative applications—from revolutionizing training protocols and simulations to reshaping design and marketing strategies. In business, VR emerges as a pivotal tool, enabling organizations to construct highly immersive and interactive training environments. These environments accelerate learning processes and deepen engagement, offering realistic simulations of workplace scenarios. Such simulations are instrumental in boosting the preparedness and response capabilities of employees, significantly enhancing operational readiness and risk management in real-world settings.

Project management within these sectors benefits greatly from VR by improving scope definition, risk assessment, and stakeholder communication. By simulating complex project scenarios, VR allows project teams to identify potential issues and test solutions in a virtual environment, which leads to better planning and decision-making.

In the educational sector, the impact of VR is equally transformative, shifting the pedagogical approach from traditional didactics to more interactive, experiential learning modalities. The work of C. Ma and colleagues [8] underlines the significant role of VR in fostering immersive educational experiences. These experiences, by simulating real-world environments in a controlled, virtual setting, enable students to engage with, explore, and understand complex subjects in innovative and intuitive ways. This method enhances student engagement and significantly deepens comprehension of theoretical concepts, allowing for hands-on interaction and manipulation of learning materials.

Additionally, VR's application in data visualization represents a leap forward in how we interpret complex data sets. As noted by M. Gall and S. Rinderle-Ma [6], VR elevates data visualization beyond traditional two-dimensional interfaces into rich, interactive three-dimensional spaces. This advancement transforms data interaction, offering users an enhanced perspective and a more nuanced understanding of intricate data structures, which is crucial for informed decision-making and effective problem-solving across business, science, and educational fields.

Incorporating VR into project management processes in educational and business environments not only streamlines project execution but also enhances outcome predictability and project deliverables. It enables project managers to conduct comprehensive feasibility studies and impact assessments with greater accuracy and less risk. By facilitating a deeper understanding and improved visualization of project goals, VR technology serves as a cornerstone for innovative project management strategies.

2.3. Methodology

2.3.1. Nested Definition Framework for VR

Addressing the complex nature of Virtual Reality (VR) technology, this study introduces a detailed nested definition framework designed to methodically differentiate among the three principal components of VR: the content, the hardware, and the user experience. This framework serves as a crucial analytical tool, enabling a detailed dissection and nuanced understanding of VR technology, thereby enhancing our comprehension of its acceptance and utilization across diverse sectors.

The VR Content Component includes all digital assets and interactive elements that make up the virtual environment, ranging from graphical and narrative elements to the software applications that facilitate these experiences. In a project management context, understanding VR content is vital for assessing project scope, deliverables, and the quality of the VR experience provided to end-users. It influences user engagement levels and is a key factor in the immersive quality of the VR environment, directly impacting project outcomes in terms of user satisfaction and technological adoption.

The VR Hardware Component involves the physical devices and equipment that allow users to interact with the virtual world. This includes a variety of devices such as head-mounted displays (HMDs), motion tracking sensors, gloves, and other tactile feedback systems. For project managers, the hardware component is critical in determining the technological requirements and procurement strategies of VR projects. It affects not only the budgeting and scheduling facets of project management but also the user experience in terms of visual clarity, motion tracking accuracy, and overall comfort and immersion.

The VR Experience Component represents the subjective perception and cognitive interaction of the user with the virtual environment, encompassing sensory, emotional, and intellectual engagement. This component is pivotal for project managers to understand as it directly influences user acceptance and the overall success of VR implementations in business or educational settings. The VR experience affects stakeholder satisfaction and is a significant determinant in the continuous improvement and iterative development of VR projects.

By employing this nested definition framework, our study provides a comprehensive view of VR technology, promoting a deeper understanding of its complex nature. This systematic approach is instrumental for project managers to effectively plan, execute, and evaluate VR projects. It facilitates the identification of critical elements that influence the success of VR technology adoption and highlights potential areas for further research and development to optimize the integration and effectiveness of VR systems in various applications.

2.3.2. Extension of the Technology Acceptance Model (TAM)

Recognizing the limitations of the traditional Technology Acceptance Model (TAM) to fully encapsulate the unique attributes of Virtual Reality (VR) technology, this study expands the model to include additional constructs. These enhancements, forming the VR Hardware Acceptance Model (VR-HAM), are crafted to specifically assess the acceptance of VR hardware, focusing notably on VR goggles.

Perceived Enjoyment is introduced as a crucial construct to capture the intrinsic motivation and enjoyment derived from using VR technology. This is particularly pertinent in project management, where the user's engagement level can directly influence the adoption and sustained use of VR systems in a business or educational setting. The entertainment and immersive nature of VR are seen as significant factors that can affect a project's acceptance rate and overall success.

External variables are incorporated into the VR-HAM to account for the broader range of factors that may affect the adoption of VR technology. Age is considered to analyze generational differences in technology adoption, essential for project managers to tailor VR solutions that meet the technological fluency of different user groups. Curiosity measures an individual's eagerness to engage with new and advanced technologies, indicating a readiness to adopt innovations that can be critical during the planning and implementation phases of VR projects.

Past use reflects on how previous experiences with VR or related technologies can ease the integration process, suggesting that familiarity may enhance user competence and comfort, thus supporting smoother project transitions. Lastly, price willingness assesses the financial impact on the decision-making process, highlighting budgetary considerations that project managers must account for when deciding on VR implementations.

By integrating these constructs into the established TAM framework, the VR-HAM offers a more detailed and nuanced understanding of the factors influencing user attitudes and behaviors towards VR technology adoption, especially regarding hardware like VR goggles. This expanded model not only aids in a deeper exploration of the complex nature of technology acceptance but also serves as a valuable tool for project managers. It enables them to strategize more effectively, ensuring that VR projects are not only technically feasible but also aligned with user expectations and budgetary constraints, thereby enhancing the potential for successful adoption and integration of VR technologies in various domains.

2.3.3. Data Collection and Sampling Procedure

For this research, a comprehensive two-stage nonprobability snowball sampling method was utilized to gather data from a diverse group of respondents, thereby capturing a broad spectrum of perspectives on Virtual Reality (VR) hardware. The first phase of this sampling strategy involved targeted outreach within the professional networks of the researchers, specifically through the LinkedIn platform. Individuals identified as having a professional or academic interest in VR technology were directly contacted and invited to participate in a detailed survey that focused on their experiences with and perceptions of VR hardware.

Upon agreeing to participate, these initial respondents were then involved in the second phase of the snowball sampling process. They were asked to share the survey link with their professional contacts who met specific eligibility criteria set by the research team to ensure relevance and a potential interest in VR technology. These criteria were deliberately designed to include individuals who either had firsthand experience with VR hardware, such as VR goggles, or those with a professional interest in the technological, educational, or business applications of VR.

The strategic use of this two-stage nonprobability snowball sampling method was intended to progressively expand the reach to a broader yet relevant segment of the population, capable of providing insightful contributions to the acceptance and usage of VR technology. This approach was designed to produce a representative sample of individuals deeply engaged with or interested in VR, thereby enhancing the validity and applicability of the research findings. The snowball sampling method proved particularly beneficial for this study as it exploited existing professional networks to access a wider and more diverse group of participants, who might otherwise be difficult to engage through conventional sampling techniques.

Employing the snowball sampling method in project management, particularly in projects involving innovative technologies like VR, provides critical advantages. This approach allows project managers to gather in-depth insights from a targeted yet expansive network of stakeholders, ensuring that the project's direction and outcomes align closely with user expectations and market needs. Furthermore, leveraging professional networks enhances stakeholder engagement, which is crucial for the iterative development and successful deployment of new technologies. This method also aids in identifying potential risks and barriers to adoption early in the project lifecycle, allowing for more informed decision-making and strategic planning.

2.3.4. Survey Instrument and Constructs Measurement

In developing the survey instrument for this study, considerable care was taken to construct a comprehensive tool capable of precisely assessing the constructs identified in the extended Technology Acceptance Model (TAM). The survey was meticulously crafted by adapting and modifying validated scales to align closely with the unique characteristics of VR technology acceptance. Core constructs of the extended TAM, such as perceived usefulness, ease of use, enjoyment, and various external variables, were operationalized through a series of carefully formulated questions.

A 5-point Likert scale was utilized to quantitatively measure these constructs, providing respondents with choices ranging from 'strongly disagree' to 'strongly agree'. This scale was instrumental in evaluating participants' attitudes and perceptions regarding the usability, utility, and enjoyment of VR hardware, facilitating a detailed analysis of how these factors influence technology acceptance.

Additionally, the survey featured a specialized section to evaluate price willingness, presenting respondents with a range of price points to determine the financial thresholds that might influence their decision to adopt VR technology. This section aimed to gather insights into price sensitivity, a crucial external factor in VR acceptance.

Another essential component of the survey was the collection of data on past usage of VR technology, where respondents were asked to self-report their previous experiences with VR devices. This information was crucial for understanding how prior exposure could affect current perceptions and levels of acceptance.

To ensure the validity and reliability of the survey instrument, the draft version underwent a rigorous review process involving marketing experts. These specialists meticulously evaluated the survey content to ensure that each question was clear, unambiguous, and directly related to the study's objectives. Their invaluable feedback was integrated into the final version of the survey, enhancing its structure and content to maximize clarity, relevance, and engagement from respondents.

This rigorous development process of the survey instrument underscores the importance of precise project planning and execution in research involving new technologies like VR. Project managers can apply similar strategies in their projects by ensuring that every tool and process is carefully designed to meet the project's specific objectives. This includes aligning project resources and activities to capture essential data that informs project direction and decision-making, ultimately leading to more successful outcomes.

Furthermore, the integration of feedback from domain experts highlights a proactive approach to quality assurance in project management. This practice not only improves the project deliverables but also enhances stakeholder trust and satisfaction, crucial for the sustained success of projects, especially in fields as dynamic and rapidly evolving as virtual reality technology.

2.3.5. Structural Equation Modeling (SEM) Analysis

In order to rigorously test the hypotheses formulated from the extended Technology Acceptance Model (TAM), this study adopts a sophisticated analytical approach known as Structural Equation Modeling (SEM). Utilizing the "lavaan package" within the R statistical software environment, SEM is employed as a powerful statistical technique to explore and elucidate the complex interrelations among the various constructs of the extended TAM. This methodological choice is predicated on SEM's ability to concurrently estimate multiple and interrelated dependence relationships, thereby facilitating a comprehensive analysis of the causal pathways within the hypothesized model.

The employment of SEM in this context is particularly apt given its capacity to handle complex model structures, including those with latent variables that represent abstract concepts like perceived usefulness, ease of use, and enjoyment, which are central to the extended TAM. Through this approach, the study endeavors to uncover the underlying dynamics that govern the acceptance of VR technology, elucidating how each construct contributes to shaping user attitudes and behavioral intentions.

In project management, particularly in projects involving the implementation of new technologies like VR, understanding these dynamics is crucial. The insights gained from the SEM analysis can inform project leaders about the key factors that influence technology adoption, enabling them to devise more effective strategies for managing change and fostering technology acceptance among stakeholders.

To ensure the methodological rigor and reliability of the SEM analysis, the study meticulously evaluates the model fit by employing a suite of fit indices. These indices include the chi-square to degrees of freedom ratio ($\chi 2/df$), which provides a basic measure of model fit relative to the model's complexity; the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI), both of which compare the fit of the hypothesized model against a baseline null model; the Root Mean Square Error of Approximation (RMSEA), which assesses the fit per degree of freedom, accounting for model complexity; and the Standardized Root Mean Square Residual (SRMR), which measures the average discrepancy between the observed and predicted correlations.

Applying these indices allows the research team to determine how well the proposed model represents the observed data. A good model fit, indicated by low $\chi 2/df$, RMSEA, SRMR values, and high CFI and TLI values, confirms the robustness of the SEM analysis and the validity of the findings. Such substantiation enhances the credibility of the hypothesized determinants of VR technology acceptance and underscores the study's commitment to empirical rigor. This comprehensive evaluation not only supports the project's scientific foundation but also ensures that project management decisions are based on validated data, enhancing the likelihood of successful technology adoption and integration.

2.4. Basic Theory of the Proposed Method

2.4.1. Theorical Framework

The VR-HAM suggests that the adoption of virtual reality technology depends on users' beliefs about its utility, simplicity, and enjoyment, along with external influences. This model is based on the subsequent hypotheses:

1) Perceived Usefulness (PU) refers to the extent to which an individual thinks that utilizing virtual reality technology will improve their work efficiency or everyday tasks.
2) Perceived Ease of Use (PEOU) indicates how much an individual expects that operating virtual reality technology will require minimal effort.
3) Perceived Enjoyment (PE) denotes how much using virtual reality technology is considered enjoyable independently of any expected performance outcomes.

To quantify the relationships among the constructs of the VR-HAM, the following formulas are proposed:

1) Formula (1) calculates the perceived usefulness of VR technology, incorporating the influences of PEOU, PE, and a summation of impacts from external variables such as age, curiosity, past use, and price willingness:

$$PU = \beta_1 \cdot PEOU + \beta_2 \cdot PE + \sum (\beta_{ext} \cdot EV), \quad (1)$$

where coefficients β_1 and β_2 represent the strength of the relationships between PEOU and PE on PU, respectively, while β_{ext} coefficients quantify the impact of each EV (external variable) on PU.

2) Formula (2) defines the PEOU of VR technology, factoring in the effect of PE and the cumulative influence of external variables:

$$PEOU = \gamma_1 \cdot PE + \sum (\gamma_{ext} \cdot EV), \tag{2}$$

where efficient γ_1 denotes the impact of PE on PEOU, and γ_{ext} coefficients measure the influence of external variables on PEOU.

3) Formula (3) expresses the intention to use VR technology, integrating the effects of PU, PEOU, and PE:

$$ITU = \delta_1 \cdot PU + \delta_2 \cdot PEOU + \delta_3 \cdot PE, \tag{3}$$

where coefficients δ_1, δ_2, and δ_3 represent the strengths of the relationships between PU, PEOU, and PE on ITU, respectively.

4) Formula (4) calculates the actual use of VR technology based on the intention to use (ITU):

$$AU = \zeta_1 \cdot ITU, \tag{4}$$

where coefficient ζ_1 indicates the degree to which ITU translates into AU.

5) Formula (5) quantifies the cumulative impact of external variables on the core constructs of the VR-HAM model:

$$EI = \sum \eta_{ext} \cdot EV, \tag{5}$$

where η_{ext} coefficients measure the influence of each external variable, providing a comprehensive view of how factors such as age, curiosity, past use, and price willingness affect the acceptance and use of VR technology.

Understanding these mathematical relationships is critical for project managers overseeing VR technology implementation projects. By comprehending how various factors influence user acceptance, project managers can tailor their strategies to address specific barriers and leverage enablers to technology adoption. This theoretical framework not only assists in predicting the outcomes of introducing VR technologies but also aids in the strategic planning of training programs, marketing strategies, and user engagement initiatives that align with the predicted model outputs. Such alignment ensures that projects are not only executed effectively but also resonate well with the target audience, thereby maximizing the likelihood of successful technology integration and adoption.

3. Results

The SEM analysis confirmed the significance of the proposed relationships within the VR-HAM. The model fit indices indicated a good fit to the data, with a $\chi 2/df$ ratio of 2.45, CFI of 0.95, TLI of 0.94, RMSEA of 0.05, and SRMR of 0.03, suggesting that the model adequately represents the observed data.

Table 1 shows the coefficients and significance levels.

Table 1
Coefficients and Significance Levels.

№	Construct Relationship	Coefficient	Standard Error	Significance
1	PEOU → PU	$\beta_1 = 0.44$	0.05	p < 0.001
2	PE → PU	$\beta_2 = 0.42$	0.04	p < 0.001
3	Pe → PEOU	$\gamma_1 = 0.56$	0.05	p < 0.001
4	PU → ITU	$\delta_1 = 0.34$	0.06	p < 0.001
5	PEOU → ITU	$\delta_2 = 0.25$	0.06	p < 0.01
6	PE → ITU	$\delta_3 = 0.3$	0.05	p < 0.001
7	ITU → AI	$\zeta_1 = 0.81$	0.04	p < 0.001

From Table 1, the coefficients (β_1, β_2, γ_1, δ_1, δ_2, δ_3, and ζ_1) represent the strength and direction of relationships between various constructs within the VR-HAM model, such as PEOU, PU, PE, ITU, and AU. The significance levels indicate the statistical reliability of these relationships. For instance, a high coefficient value with a low p-value ($p < 0.001$) for the relationship between PEOU and PU suggests a strong and statistically significant positive influence of ease of use on the perceived usefulness of VR technology. This table underscores the critical pathways through which different perceptions about VR technology influence user intentions and behaviors.

Table 2 shows the summary statistics for primary variables.

Table 2
Summary Statistics for Primary Variables.

№	Variable	Mean	Variability Measure
1	Perceived Usefulness (PU)	3.8	0.76
2	Perceived Ease of Use (PEOU)	4.2	0.82
3	Perceived Enjoyment (PE)	4.5	0.78
4	Intention to Use (ITU)	4.0	0.85
5	Actual Use (AU)	3.7	0.89

Table 2 displays average perceptions and behaviors towards VR technology, detailing mean and standard deviation for key variables like PU, PEOU, PE, ITU, and AU. High mean values, especially for PE, alongside low standard deviations, indicate a consensus on VR's enjoyability among respondents. This table succinctly captures overall attitudes and behaviors towards VR among participants.

Table 3 shows the impact of external variables on PEOU and PU.

Table 3
Impact of External Variables on PEOU and PU.

№	External Variable	Impact on PEOU (γ_{ext})	Impact on PU (β_{ext})
1	Age	-0.15	-0.1
2	Curiosity	0.25	0.2
3	Past Use	0.31	0.36
4	Price Willingness	0.2	0.25

Table 3 demonstrates the impact of external variables (age, curiosity, past use, and price willingness) on PEOU and PU. Positive values denote a positive influence, while negative values indicate a negative impact. For instance, curiosity positively affects both PEOU and PU, suggesting that more curious individuals find VR technology easier to use and more useful. Conversely, age negatively impacts PEOU and PU, indicating that older participants find VR technology less user-friendly and useful. This table underscores the importance of demographic and psychological factors in understanding and predicting VR technology acceptance.

The results show that PE is a crucial driver of both PU and PEOU, emphasizing the significance of enjoyable experiences in VR technology acceptance. The strong relationship between ITU and AU suggests that users intending to use VR technology are likely to follow through with actual usage. External variables, especially past use and curiosity, significantly influence the core constructs of the VR-HAM, highlighting the need for targeted strategies to enhance user engagement and acceptance.

From a project management perspective, these insights are invaluable for planning and executing VR projects. Understanding that external variables, particularly past use and curiosity, significantly influence the core constructs of the VR-HAM, provides a basis for tailored strategies to enhance user engagement and acceptance. Project managers can use this information to tailor VR implementations to specific user groups, ensuring interventions maximize ease of use and enjoyment, thereby fostering higher acceptance rates. These findings offer valuable guidance for developers, marketers, and educators in effectively implementing and promoting VR applications.

4. Conclusion

Thus, this study's investigation into the acceptance and integration of Virtual Reality technology, utilizing an extended Technology Acceptance Model (VR-HAM), has yielded significant insights into the dynamics of VR adoption across business and educational contexts. By analyzing data through Structural Equation Modeling (SEM) and interpreting results from various constructed tables, we have derived a nuanced understanding of how perceived usefulness, perceived ease of use, perceived enjoyment, and external variables collectively influence attitudes towards VR technology. This section summarizes these findings, incorporating the mathematical data obtained, and collates insights into the strategic implications for VR technology adoption. Key Findings:

1) The study highlighted PE as a critical driver, with a standardized path coefficient of 0.56 to PEOU and 0.42 to PU, underscoring the importance of engaging experiences in VR technology acceptance.
2) External variables showed significant impacts on the core constructs of the VR-HAM. Notably, past use had a strong positive influence on PU ($\beta_{ext} = 0.36$) and PEOU ($\gamma_{ext} = 0.31$), indicating that previous interactions with VR technology positively affect its perceived utility and ease of use.
3) The relationship between ITU and AU was robust, with a coefficient of 0.81, suggesting that intentions are highly predictive of actual engagement with VR technology.
4) The data reveal VR technology's transformative potential, particularly in enhancing operational efficiency and learning outcomes. The significant role of perceived enjoyment in technology acceptance suggests that immersive and engaging VR experiences are crucial for wider adoption.

This study's findings are invaluable for project managers tasked with implementing VR technology. Understanding that engaging experiences and ease of use are pivotal to adoption can guide the development of user-centered VR applications. Additionally, recognizing the impact of past usage encourages project managers to consider introductory sessions or demos as part of the deployment strategy to increase user familiarity and comfort.

Furthermore, the strong correlation between intentions and actual use suggests that ensuring initial user buy-in through effective communication and stakeholder engagement is crucial. By addressing these aspects, project managers can significantly enhance the likelihood of successful VR integration.

References

[1] J. Steuer, “Defining virtual reality: Dimensions determining telepresence,” Mathematical Problems in Engineering, vol. 42, no. 4, pp. 1-10, December 2022. URL: https://doi.org/10.1111/J.1460-2466.1992.TB00812.X.

[2] F. P Brooks, “What's real about virtual reality?,” IEEE Computer Graphics and Applications, vol. 19, no. 6, pp. 16-27, March 1999. URL: https://doi.org/10.1109/38.799723.

[3] L. P. Berg, and J. M. Vance, “Industry use of virtual reality in product design and manufacturing : A survey,” Virtual Reality, vol. 21, no. 1, pp. 1-17, March 2017. URL: https://doi.org/10.1007/s10055-016-0293-9.

[4] S. C. Jang, and Y. Namkung, “Perceived quality, emotions, and behavioral intentions : Application of an extended Mehrabian-Russell model to restaurants,” Journal of Business Research, vol. 62, pp. 451-460, April 2009. URL: https://doi.org/10.1016/j.jbusres.2008.01.038.

[5] M. V. Rosing, S. White, F. A. Cummins, and H. D. Man, “Business Process Model and Notation – BPMN,” 2 The Complete Business Process Handbook, vol. 1, pp. 433-457, 2015. URL: https://doi.org/10.1016/B978-0-12-799959-3.00021-5.

[6] M. Gall, and S. Rinderle-Ma, "Visualizing Multiple Process Attributes in one 3D Process Representation," ArXiv, abs/1903.00283, pp. 1-19, March 2019. URL: https://arxiv.org/pdf/1903.00283.pdf.

[7] B. St-Aubin, G. A. Wainer, and F. Loor, "A Survey of Visualization Capabilities for Simulation Environments," 2023 Annual Modeling and Simulation Conference (ANNSIM), pp. 13-24, May 2023.

[8] C. Ma, W. Chen, and Y. Tian, "Simulation Model of Sports Entrepreneurship Performance Based on Wireless Sensor Network," Wireless Communications and Mobile Computing, vol. 2021, pp. 1-16, October 2021. URL: https://doi.org/10.1155/2021%2F2464505.

[9] F. D. Davis, "A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results," IA Sloan School of Management, Massachusetts Institute of Technology, pp. 1-292, February 1986.

[10] V. Venkatesh, M. G. Morris, and F. D. Davis, "User acceptance of information technology: Toward a unified view," Institutions & Transition Economics: Microeconomic Issues eJournal, vol. 27, no. 3, pp. 425-478, September 2003. URL: https://doi.org/10.2307/30036540.

[11] N. Christoff, N. N. Neshov, K. Tonchev, and A. H. Manolova, "Application of a 3D Talking Head as Part of Telecommunication AR, VR, MR System: Systematic Review," Electronics, vol. 12, no. 23, pp. 1-25, November 2023. URL: https://doi.org/10.3390/electronics12234788.

[12] I. Ajzen, and M. Fishbein, "Understanding Attitudes and Predicting Social Behavior," Englewood Cliffs, NJ: Prentice Hall, vol. 278, pp. 289-311, March 1980.

[13] H. E. Sumbul, T. F. Wu, Y. Li, S. S. Sarwar, W. Koven, E. Murphy-Trotzky, X. Cai, E. Ansari, D. H. Morris, H. Liu, D. Kim, and E. Beigné, "System-Level Design and Integration of a Prototype AR/VR Hardware Featuring a Custom Low-Power DNN Accelerator Chip in 7nm Technology for Codec Avatars," 2022 IEEE Custom Integrated Circuits Conference (CICC), pp. 1-8, April 2022. URL: https://doi.org/10.1109/CICC53496.2022.9772810.

[14] E. Holdack, and K. Lurie-Stoyanov, "Experiencing Virtual Reality in Retail: Extending the Acceptance Model for Vr Hardware Towards VR Experiences," Journal of Business Research, pp. 1-44, November 2021. URL: https://doi.org/10.2139/ssrn.3876097.

[15] R. Zhang, and L. Li, "Research on Evolutionary Game and Simulation of Information Sharing in Prefabricated Building Supply Chain," Sustainability, vol. 15, no. 13, pp. 1-24, June 2023. URL: https://doi.org/10.3390/su15139885.

[16] S. Dolhopolov, T. Honcharenko, S. A. Dolhopolova, O. Riabchun, M. Delembovskyi, and O. Omelianenko, "Use of Artificial Intelligence Systems for Determining the Career Guidance of Future University Student," 2022 IEEE International Conference on Smart Information Systems and Technologies (SIST), pp. 1-6, April 2022. URL: https://doi.org/10.1109/SIST54437.2022.9945752.

[17] D. Chernyshev, G. Ryzhakova, T. Honcharenko, H. Petrenko, I. Chupryna, and N. Reznik, "Digital Administration of the Project Based on the Concept of Smart Construction," in ICBT 2022: Explore Business, Technology Opportunities and Challenges After the Covid-19 Pandemic. Lecture Notes in Networks and Systems, vol. 495, pp. 1316-1331, July 2022. URL: https://doi.org/10.1007/978-3-031-08954-1_114.