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Fun Over Function: The Role of Social Influence and Hedonic Motivation in Virtual Reality Adoption for Biology Education

Umar Abdul Labib*
Universitas Muhammadiyah Metro, INDONESIA

Dasrieny Pratiwi
Universitas Muhammadiyah Metro, INDONESIA

Beny Saputra
Universitas Muhammadiyah Metro, INDONESIA

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Abstract

Background: The integration of Virtual Reality (VR) into higher education offers new possibilities for teaching intricate scientific subjects like biology. This medium provides interactive simulations that support hands-on learning. However, maximizing its potential requires a clear understanding of student acceptance.
Aims: This research investigates the specific factors that shape the behavioral intention of pre-service biology teachers to utilize VR as a learning medium.
Methods: Data was collected from 143 participants following a practical VR simulation session. The study applied a customized Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) framework, and the analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM).
Results: The tested model accounted for 31.4% of the variance in behavioral intention ($R^2 = 0.314$). The findings highlight that social and emotional variables are the main catalysts for initial adoption. Both Social Influence (SI) ($\beta = 0.261$, $p < 0.05$) and Hedonic Motivation (HM) ($\beta = 0.250$, $p < 0.05$) exerted significant positive effects. Conversely, the utilitarian variables named Performance Expectancy (PE) ($\beta = 0.056$, $p > 0.05$) and Effort Expectancy (EE) ($\beta = 0.118$, $p > 0.05$) did not show statistical significance.
Conclusion: Initial acceptance of immersive technologies in this context is predominantly influenced by peer dynamics and the perceived enjoyment of the tool, rather than utilitarian evaluations.

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INTRODUCTION

The contemporary framework of higher education is undergoing a rapid digital transformation, necessitating that academic institutions incorporate sophisticated immersive technologies into their educational practices (Chadha, 2024; Marks & AL-Ali, 2020). The advent of Virtual Reality (VR) has positioned it as a prominent tool in education, significantly transforming conventional learning environments (Quarder et al., 2025). Opposed to typical flat resources like printed books or static presentation visuals that restrict students to the role of passive onlookers, VR entirely submerges learners in computer-generated, immersive three-dimensional worlds (Alhawsawi & Alzaid, 2025; Allcoat & Mühlenen, 2018). Technological improvements facilitate students' movement towards being active participants who can immediately engage with and modify online items. With the application of multisensory involvement, VR fosters an engaging learning environment that research has clearly shown to substantially increase student drive and focus (Cevikbas et al., 2025). As a result, this immersive learning medium provides a sophisticated mechanism to cultivate a much deeper and more robust conceptual understanding of intricate academic subjects than was previously achievable through conventional instructional methodologies (Paech et al., 2023).

In biology education, VR as a learning medium is applied to address specific challenges related to the visualization of dynamic biological systems (Sharif et al., 2025; Tolentino & Varela, 2025). Fundamental concepts, including cellular metabolic pathways, DNA replication, and protein synthesis, involve microscopic mechanisms that can be difficult to represent accurately using static

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*** Corresponding author:**
Umar Abdul Labib, Universitas Muhammadiyah Metro, Indonesia. ✉umar.labib1@gmail.com

diagrams or textbooks (Chandrasekaran et al., 2021). Traditional materials may not fully convey the spatial relationships and temporal changes inherent in these living systems. VR technology provides a platform for students to observe biochemical processes in a simulated environment (Coan et al., 2020). By utilizing this learning media, students can visualize the structural organization of cells and the interactions between various molecular components (Reen et al., 2021). This approach is intended to provide a link between theoretical descriptions and the spatial organization of biological functions (Ricca et al., 2023). The capacity of VR to simulate microscopic environments provides students with a tool to explore structures that are generally inaccessible in a standard classroom. Consequently, VR simulations are considered a functional option for presenting scientific topics that require detailed spatial representation in higher education (Wanselin & Danielsson, 2023).

The use of VR as a learning medium also provides a response to certain practical and ethical considerations in traditional laboratory settings (Beatrice et al., 2024; C. Yang et al., 2024). Physical laboratory practicums are sometimes constrained by factors such as the procurement costs of specialized equipment, safety protocols for handling hazardous materials, and limited access to specific biological specimens (Kismiati et al., 2022). Furthermore, ethical discussions regarding the use of animals for dissection in education have prompted the exploration of virtual alternatives. VR simulations offer a way for students to perform virtual dissections and laboratory procedures without requiring physical biological samples or exposure to real-world risks. This learning media enables the replication of laboratory environments, allowing for the repeated practice of procedures in a resource-efficient manner (Ko & Choi, 2024). By providing virtual laboratory experiences, institutions can offer training that adheres to institutional safety standards and ethical guidelines. These digital alternatives are designed to support skill development while addressing logistical challenges associated with physical facilities. Thus, VR represents a pragmatic addition to contemporary science education infrastructure (Choi & Choi, 2024).

While the pedagogical benefits of VR are well documented, establishing its empirical benefits alone is insufficient. Identifying the determinants of its adoption is critical because substantial institutional investments in immersive technologies will yield minimal returns if end users reject the medium. Furthermore, investigating this technology acceptance specifically among pre-service biology teachers is imperative. In the context of the growing use of immersive learning technologies in science education, pre-service teachers act as future pedagogical agents. Their initial technology acceptance not only dictates the quality of their current conceptual understanding but also fundamentally shapes their future willingness to integrate immersive technologies into secondary biology education. Although extensive research has examined VR's pedagogical effectiveness, empirical studies explicitly examining the antecedents of VR acceptance remain disproportionately concentrated in medical and engineering training (Tran & Meacheam, 2020). Consequently, a distinct research gap remains regarding the drivers of initial adoption among undergraduate pre-service biology teachers. Furthermore, previous technology acceptance literature relied on foundational frameworks such as the Technology Acceptance Model (TAM). However, recent studies argue that TAM's utilitarian focus is inadequate for capturing the spectrum of voluntary technology adoption because it critically overlooks affective and social determinants such as hedonic motivation and peer influence (Y.-F. Yang & Fan, 2025). Furthermore, the theoretical frameworks used in prior studies, such as the basic Technology Acceptance Model (TAM), may be insufficiently comprehensive. These models often overlook important non-utilitarian determinants, such as hedonic motivation (enjoyment), price value, and habit, all of which influence students' voluntary use of technology. This gap warrants further empirical investigation.The scientific community requires empirical studies that apply modern, comprehensive theoretical models to understand VR acceptance within this specific student population (Abuhassna et al., 2023).

To address this gap, this study employs a modified Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) framework, which has been recognized in recent literature Kułak et al. (2019) and Strzelecki (2024) for its robust capacity to synthesize utilitarian and non-utilitarian factors. Therefore, this research aims to empirically investigate the determinants shaping pre-service biology teachers' behavioral intention to use VR. Specifically, the expected contribution of this study is to validate the UTAUT2 model in a novel pedagogical context and to provide data-driven insights into whether initial VR adoption in biology education is driven by functional utility or by hedonic and social appeal (Venkatesh et al., 2012). The UTAUT2 model was chosen due to its reputation as one of the most comprehensive technology acceptance frameworks. It expands upon prior theories by incorporating a more holistic view of user behavior, making it well-suited to the context of students considering a new learning tool. Applying the UTAUT2 model enables this study to quantitatively test a range of antecedents, including both utilitarian and hedonic factors (e.g., hedonic motivation) (Latief et al., 2022). This approach will yield a nuanced understanding of students' perceptions of VR.

METHOD

This study applied a quantitative cross-sectional design to examine the variables affecting VR acceptance among pre-service biology teachers (El Haddaoui et al., 2025). The conceptual model was derived from the UTAUT2 framework (Venkatesh et al., 2012). Focusing on four independent constructs: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Hedonic Motivation (HM). The primary dependent variable was the Behavioral Intention (BI) to use VR. Based on this theoretical framework, four main hypotheses were formulated for testing:

H1: BI is positively and significantly influenced by PE.

H2: BI is positively and significantly influenced by EE.

H3: BI is positively and significantly influenced by SI.

H4: BI is positively and significantly influenced by HM.

Figure 1 depicts the conceptual framework and the proposed connections between these variables.

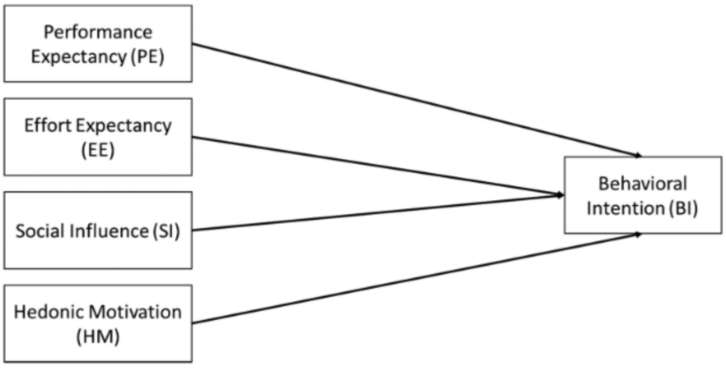

Figure 1. The Modified UTAUT2 Model

Data were collected from 143 undergraduate students (S1) currently enrolled in the Biology Education program. A purposive sampling technique was used to select participants based on specific criteria: active enrollment in the academic program and attendance at the VR intervention session. This non-probability sampling method was deemed appropriate because it targets individuals who represent the specific population of interest, current science learners evaluating a new educational tool. Consistent with the study's objective of measuring initial acceptance, the majority of selected participants (86.01%) reported having no substantial prior experience using Virtual Reality for educational purposes. Each participant engaged in a 15-minute VR biology simulation before completing the questionnaire, ensuring that their responses reflected actual hands-on experience rather than purely theoretical assumptions (Or, 2023). The intervention phase consisted of a controlled, researcher-guided VR session. Initially, participants received an orientation outlining the learning objectives and standard operating instructions for the VR hardware. Subsequently, the students interacted with a biology-based VR simulation specifically focused on human digestive organs and systems. The duration of the VR interaction was standardized to 15 minutes per participant. While relatively brief, this duration is considered adequate for initial technology exposure to elicit a preliminary behavioral intention while minimizing the potential risk of cybersickness or visual fatigue associated with prolonged VR use among inexperienced users. An online research questionnaire was distributed to participants and completed immediately after they finished the VR trial session. This approach ensured that all recorded responses were based on actual usage experience rather than theoretical perceptions. Participation in the study was entirely voluntary. The researchers guaranteed data anonymity and obtained informed consent from all respondents before the session began (Sharma et al., 2024).

The survey instrument drew upon the established UTAUT2 framework. Specifically, the indicators used to measure PE, EE, SI, HM, and BI were modified from the validated scales originally introduced by Venkatesh et al. (2012). Each item was measured using a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). This study deliberately excluded three other UTAUT2 constructs (Price Value, Habit, and Facilitating Conditions). The justification for this exclusion was the research context: Price Value was irrelevant because participants did not purchase the VR technology; Habit was inapplicable because participants were interacting with VR for the first time. Before the primary data collection phase, a pilot study with 20 undergraduate biology students of comparable academic profiles was conducted to assess the clarity of the instructions and the readability of the survey instrument.

Responses gathered from 143 participants were processed utilizing SmartPLS 4.0. Partial Least Squares Structural Equation Modeling (PLS-SEM) was selected as the analytical approach due to its suitability for exploratory research models and its robustness in handling non-normally distributed data (Hair & Alamer, 2022). The evaluation procedure was conducted in two sequential stages. First, the measurement model was assessed to establish reliability and validity. Construct reliability was verified using Composite Reliability (CR) with a threshold of >0.70, while convergent validity was determined using the Average Variance Extracted (AVE) >0.50. Discriminant validity was evaluated by applying the Heterotrait-Monotrait (HTMT) ratio with a conservative threshold of <0.85. In the second stage, the structural model was evaluated to test the formulated hypotheses. Path coefficients (β) and significance levels (p-values) were computed utilizing a bootstrapping procedure with 5,000 subsamples to ensure statistical robustness. Finally, the model's overall predictive capacity was determined by the coefficient of determination (R^2).

RESULTS AND DISCUSSION

Results

Data was obtained from 143 participants who took part in the study. All respondents were active students in a Biology Education program. Descriptive analysis revealed that the majority of respondents were female (91.61%), while 8.39% were male. Participant ages ranged from 17 to 22 years, with an average age of 19. Most students were in their third semester. In line with the sampling criteria, the vast majority of participants (86.01%) reported having no prior substantial experience using Virtual Reality for educational purposes before the research intervention session.

The measurement model demonstrated robust internal consistency and validity. Construct reliability was established across all five constructs (PE, EE, SI, HM, and BI), with Composite Reliability (CR) ranging from 0.761 to 0.956, exceeding the recommended 0.70 threshold. Additionally, convergent validity was confirmed; the Average Variance Extracted (AVE) for each construct ranged from 0.661 to 0.880, surpassing the 0.50 minimum requirement and indicating that each construct explains more than 50% of the variance of its items. Furthermore, all individual outer loadings onto their respective constructs ranged from 0.751 to 0.954, which is above the 0.70 benchmark, indicating strong item-level validity. Finally, discriminant validity was evaluated using the Heterotrait-Monotrait ratio (HTMT) criterion. All HTMT values between construct pairs ranged from 0.428 to 0.742, which is below the conservative threshold of 0.85 and clearly satisfies the 0.90 threshold. Collectively, these results confirm that the measurement instrument for this study is highly reliable and valid. Detailed results of the item loadings, CR and AVE values, and the HTMT matrix are presented in Tables 1-3.

Table 1. Measurement Model Assessment (Reliability and Convergent Validity)

Construct	Cronbach's alpha	Composite reliability (ρ_α)	Composite reliability (ρ_c)	Average variance extracted (AVE)
BI	0.918	0.925	0.948	0.859
EE	0.880	0.891	0.926	0.806
HM	0.932	0.934	0.956	0.880

Construct	Cronbach's alpha	Composite reliability (ρ_{α})	Composite reliability (ρ_c)	Average variance extracted (AVE)
PE	0.886	0.937	0.928	0.810
SI	0.743	0.761	0.853	0.661

Table 2. Matrix Heterotrait-Monotrait Ratio (HTMT)

	BI	EE	HM	PE	SI
BI					
EE	0.475				
HM	0.522	0.742			
PE	0.428	0.737	0.730		
SI	0.540	0.547	0.562	0.519	

After the validity and reliability of the measurement model were established, the next step was to evaluate the structural model to test the four research hypotheses. The initial result showed that the proposed model had a moderate predictive power for Behavioral Intention (BI). The coefficient of determination ($R^2 = 0.314$) indicates that the four independent constructs collectively explain 31.4% of the variance in Behavioral Intention. The results of the individual hypothesis tests, obtained through a bootstrapping procedure summarized in Table 3, revealed significant findings, Social Influence (SI) was found to be the strongest predictor, exhibiting a positive and significant influence on Behavioral Intention (H3: $\beta = 0.261$, $p = 0.010$), thus H3 is supported. Hedonic Motivation (HM) also showed a positive and significant influence on Behavioral Intention (H4: $\beta = 0.250$, $p = 0.038$), thus H4 is supported. Contrary to traditional technology acceptance models, the two utilitarian antecedents were found to be non-significant. Performance Expectancy (PE) did not show a significant effect (H1: $\beta = 0.056$, $p = 0.641$), thus H1 is rejected. Similarly, Effort Expectancy (EE) was also found to have no significant influence (H2: $\beta = 0.118$, $p = 0.354$), thus H2 is rejected.

Table 3. Structural Model Assessment and Hypothesis Testing

Hypothesized Path	Path Coefficient (β)	Sample mean	Standard Error (SE)	t-value	p-value
EE -> BI	0.118	0.111	0.127	0.928	0.354
HM -> BI	0.250	0.241	0.120	2.080	0.038
PE -> BI	0.056	0.071	0.121	0.467	0.641
SI -> BI	0.261	0.268	0.102	2.562	0,010

Discussion

This study aimed to identify the factors shaping pre-service biology teachers' intention to use Virtual Reality (VR) as a learning medium to support their own conceptual understanding, evaluated immediately after their initial practical experience with human digestive system and organ simulations. The structural equation modeling results indicate that emotional and social elements played a more prominent role than practical utility during this introductory phase. This phenomenon is supported by the significant impact of Hedonic Motivation (HM) and the lack of statistical significance for Performance Expectancy (PE). Given that the majority of participants were interacting with VR technology for the first time to study digestive anatomy, their engagement was largely exploratory and driven by curiosity about the immersive organ visualizations. The novelty effect emerging from the three-dimensional environment appeared to be a much stronger driver for usage than any rational evaluation of how the technology might directly improve their academic performance or learning outcomes. The non-significance of Performance Expectancy (PE) indicates a theoretical divergence from foundational technology acceptance frameworks, such as the original TAM, which heavily prioritize utilitarian value. Instead, these findings align with recent theoretical perspectives suggesting that during the initial introduction stage, users tend to overlook long-term functional benefits in favor of sensory stimulation. The inherent entertainment value of VR serves as a critical catalyst for deeper pedagogical integration, confirming the perspectives of Hamilton et al. (2021).

In addition to hedonic factors, Social Influence (SI) emerged as a significant predictor in this model, indicating that VR adoption in an educational context is closely tied to peer dynamics and instructor expectations. A supportive social environment encouraged students to try a technology they had never used before. Meanwhile, the non-significance of Effort Expectancy (EE) can be attributed to the high level of digital literacy among contemporary students, who intuitively expect modern digital tools to feature user-friendly interfaces. Furthermore, the lack of significance for Effort Expectancy (EE) expands upon the theoretical discourse surrounding digital natives. Consistent with Monteiro et al. (2024), this finding confirms that for contemporary pre-service biology teachers, operational ease is no longer perceived as a motivating determinant for adoption, but rather as an expected, fundamental prerequisite. This finding implies that, for pre-service biology teachers, technical barriers are no longer a significant determining factor due to their existing confidence in navigating various digital platforms. Consequently, students' intention to continue using VR is not primarily influenced by the simplicity or complexity of the device's operation, but rather by the extent to which the tool provides an enjoyable learning experience supported by positive social norms within their academic environment. Educational institutions should cultivate a supportive social ecosystem and visually engaging content to ensure the sustained use of this immersive technology.

Implications

The findings imply that the early adoption of Virtual Reality within academic environments is primarily a social and affective phenomenon rather than a rational-utilitarian decision. In this context, social influence and hedonic motivation act as critical 'gateway constructs' that govern initial acceptance. Consequently, traditional technology implementation strategies in higher education that rely exclusively on utility-driven narratives, such as emphasizing how VR will directly improve academic grades, may not be optimally effective during the initial introductory phase, as the data shows PE was non-significant (Geriş & Kulaksız, 2025). Instead, early acceptance is highly contingent upon the social environment and the inherent enjoyment derived from the technology itself.

Research Contribution

This study makes a distinct contribution to the existing literature on technology acceptance by demonstrating that during the initial introduction of immersive technologies, pre-service biology teachers' adoption decisions are predominantly driven by social norms and perceived enjoyment rather than rational cognitive evaluations of utility. This conclusion validates and extends recent observations by Lee et al. (2025), who similarly reported that novelty and hedonic factors overshadow instrumental utility during the early stages of VR implementation. This finding diverges from classic technology acceptance models, such as TAM and UTAUT, which generally identify Performance Expectancy as the primary driver of intention (Garone et al., 2019), traditional utilitarian antecedents specifically Performance Expectancy (PE) and Effort Expectancy (EE) were found to be non-significant (Ateş & Kölemen, 2025). Furthermore, this research highlights the evolving expectations of contemporary 'digital native' students, for whom ease of use is considered a baseline standard rather than an added value. The findings also provide empirical evidence that highly enjoyable, immersive experiences can effectively override rational considerations regarding the effort required to adopt new pedagogical tools, as enjoyment is more readily accepted by users as a reason for adopting to a new technology (Noble et al., 2022).

Limitations

Despite its contributions, this study acknowledges several limitations. The relatively short duration of the intervention session likely amplified the technology's novelty or 'wow factor' at the expense of revealing its long-term pedagogical benefits (Feng et al., 2025). Additionally, because the vast majority of participants (86%) were first-time VR users, the findings primarily capture the initial exploratory phase of adoption and may not accurately predict sustained, long-term usage intentions. Finally, the highly controlled nature of the researcher-guided trial sessions may have artificially eliminated practical barriers to use, thereby neutralizing the perceived effort and limiting the generalizability of the Effort Expectancy findings to independent, real-world usage scenarios (Nazari-Shirkouhi et al., 2023).

Suggestions

To effectively integrate VR into university curricula, institutions should adopt a dual strategy that capitalizes on both social and affective drivers. To leverage social influence, university administrators and faculty should actively secure endorsements from respected figures, such as senior lecturers or peer leaders, to model and promote VR usage. Educators are encouraged to design VR experiences as collaborative or socially evaluated activities to reinforce positive peer norms and create a constructive social pressure to join in (Özel, 2025). Furthermore, to maximize hedonic motivation, instructional designers must prioritize the initial user experience. The first biology simulations introduced to students must be fundamentally engaging, visually immersive, and highly enjoyable, focusing on capturing students' interest and the "wow factor" before introducing modules with high pedagogical complexity. Moreover, to address the methodological limitations identified in this study, future research should transition from cross-sectional designs to longitudinal studies. Investigating students' behavioral intentions over an extended academic semester would clarify whether hedonic motivation remains dominant or whether utilitarian factors, such as Performance Expectancy, become significant once the initial novelty effect diminishes. Additionally, future studies are encouraged to involve diverse cohorts with varying levels of prior VR experience to further validate the evolving dynamics of immersive technology acceptance (Dhume-Shinkre et al., 2025).

CONCLUSION

The analysis indicates that utilitarian aspects, specifically Performance Expectancy and Effort Expectancy, did not significantly determine the students' behavioral intention to use VR. Instead, the initial phase of adoption was primarily shaped by social and emotional factors, with Social Influence and Hedonic Motivation functioning as the main predictors. Overall, the proposed model captured 31.4% of the variance in behavioral intention. These findings suggest that when introducing new immersive tools, focusing solely on pedagogical utility may not be sufficient to drive student acceptance. Implementation strategies might be more effective if they incorporate social support mechanisms and ensure a highly engaging initial user experience.

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AUTHOR CONTRIBUTION STATEMENT

U.A.L. conceived the main idea, developed the research framework, performed the primary data analysis, and led the drafting of the manuscript. D.P. contributed to the data processing, provided critical analysis of the results, and assisted in developing the draft. B.S. managed the data gathering phase, executed the literature review, and completed the manuscript's final proofreading and editing. The final submitted version has been reviewed and approved by all contributing authors.

AI DISCLOSURE STATEMENT

The author used Google Gemini during the preparation of this work to refine the academic English phrasing. Following the use of this AI tool, the author carefully examined and revised the generated text, assuming complete accountability for the final published material.

CONFLICTS OF INTEREST

The authors confirm the absence of any financial conflicts or personal ties that might be perceived as affecting the research presented in this study.

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