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Virtual Reality in Adaptive Learning: Identifying Learning Styles and Integration in Educational Apps

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Abstract
The increasing demand for personalized education in digital environments has highlighted the limitations of traditional, static learning methods. This study addresses the challenge of accommodating diverse learning preferences and emotional responses by leveraging Virtual Reality (VR) to create immersive, adaptive learning systems. The research focuses on designing a VR-based educational framework that integrates artificial intelligence to personalize instruction, monitor emotional states, and support ethical assessment. A primary goal is to identify how students' learning styles and emotional conditions influence their experience in VR, and how educational systems can adapt in real time to these factors. Key components of the proposed system include customizable AI tutors that resemble familiar figures to boost learner motivation, real-time emotion detection during virtual exams, and cognitive load management through adaptive content delivery. Methods involve tracking emotions through facial analysis, monitoring gaze, and providing physiological feedback to dynamically adjust test environments. The findings suggest that while VR enhances engagement and satisfaction, excessive sensory input can lead to cognitive strain, underscoring the importance of balanced immersion. The study contributes a novel, emotion-driven VR framework that combines personalization, gamification, and ethical monitoring. This integrated approach provides a foundation for inclusive, engaging, and effective virtual learning systems that align with individual learner needs and support academic integrity.

Keywords: *Virtual Reality, Emotion Driven Learning, Artificial Intelligence, Cognitive Load, Personalized Education.*

I. INTRODUCTION

Personalized education has increasingly adopted immersive VR technologies to foster interactive and engaging educational outcomes, paving the way for innovation and technological integration into education through interactive methods that enhance immersive educational experiences and support educational development (Huang et al., 2019). Immersive VR offers students a virtual, interactive educational experience that enhances learning and education. The integration of VR can help identify and support diverse learning styles among students (Asad & Hussain, 2021). A digital environment can be enhanced with immersive VR to improve interactivity and assessment, providing a more personalized approach to integrating an interactive digital environment for educational purposes, thereby driving the development and operation of educational apps (Gracia & Torres, 2021). The use of VR as a tool for delivering adaptive instructions facilitates the

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development of simulated educational programs and educational apps related to behavioral activities, such as understanding student learning styles (Nguyen & Chen, 2023). This study examines how immersive VR platforms can dynamically adapt to individual learner needs, considering their use in the digital education environment as a means of recognizing student learning styles and integrating them into education apps for a personalized, technology-integrated education experience in a digital environment (Marougkas et al., 2023).

II. LITERATURE REVIEW

A. Multimodal Learning and VR

Virtual Reality (VR) plays a vital role in multimodal adaptive learning by combining visual, auditory, and kinesthetic methods to create immersive educational experiences. It enhances engagement (Lui et al., 2025), accommodates diverse learning preferences, and provides opportunities for experiential and interactive learning. VR also tailors education to meet individual needs, ensuring personalized learning paths (Chiossi et al., 2023). This multimodal approach underpins the application of VR across diverse educational fields, as illustrated below.

In business education, VR serves as an effective training tool, particularly for teaching customer relationship management. By using VR simulations, students practice managing shop-related tasks, engaging with virtual customers, and receiving instant feedback on their actions. Following the activity, classroom discussions are conducted to reflect on learning outcomes. While assessments are completed using traditional methods such as written tests, the VR component enhances the learning process by providing an engaging and realistic environment. This approach supports active, experiential learning, enabling students to gain a deeper understanding of operational management principles.

VR provides a practical platform for medical students, particularly those studying neurosurgery, to explore brain anatomy through 3D neuroimaging reconstructions. The simulations include patient data augmented with artificial markers, such as tumors, for students to analyze and measure. This method fosters spatial reasoning and navigation skills, which are essential for medical training. A collaborative mode enables interaction between students and instructors, facilitating discussions on complex scenarios. This VR-based approach offers a cost-effective and safe alternative to traditional methods, such as cadaver-based training, allowing students to refine their skills through virtual experimentation (Nasri, 2025).

In engineering education, VR is used to teach process engineering concepts by offering an interactive platform that visualizes workflows, equipment, and layouts within a virtual environment. Students work collaboratively with instructors, exploring 3D models and performing simulations that deepen their understanding of complex systems. This VR tool complements traditional learning methods, such as lectures and group assignments, providing a multimodal educational experience. By fostering collaboration, critical thinking, and problem-solving skills, VR equips students with the abilities required in professional engineering settings (Philippe et al., 2020).

Gamification has been applied within the MedChemVR virtual reality (VR) platform to enhance the teaching and learning of medicinal chemistry. Traditional teaching methods, such as 2D visuals and static models, often limit students' understanding of complex chemical structures. To address this issue, researchers integrate gamification into an immersive VR environment, offering a more interactive and dynamic approach to education (Zhang & Wang, 2022). MedChemVR enables students to interact with 3D molecular models in a virtual environment, where they can complete tasks such as assembling molecules by combining virtual atoms, each color-coded. These tasks are time-sensitive, encouraging active participation and strengthening problem-solving skills. The platform also features a comparison tool, enabling students to validate their models against the correct molecular structure and receive immediate feedback to enhance their learning.

As shown in Figure 1, the proposed framework combines personalization, emotional tracking, and gamification to enhance engagement and adaptivity in VR learning (Gracia & Torres, 2021). MedChemVR is designed for accessibility, functioning with affordable headsets and smartphones, which makes it practical for students beyond traditional laboratory settings. The paper highlights how the integration of gamification and VR fosters a personalized and engaging educational experience, leading to better comprehension, retention, and application of complex scientific concepts. This innovative approach aims to bridge gaps in traditional education and provide a more effective and engaging way to learn (Falah et al., 2021). This model illustrates how emotion detection, adaptive feedback, and VR interactivity work together to deliver personalized educational outcomes.

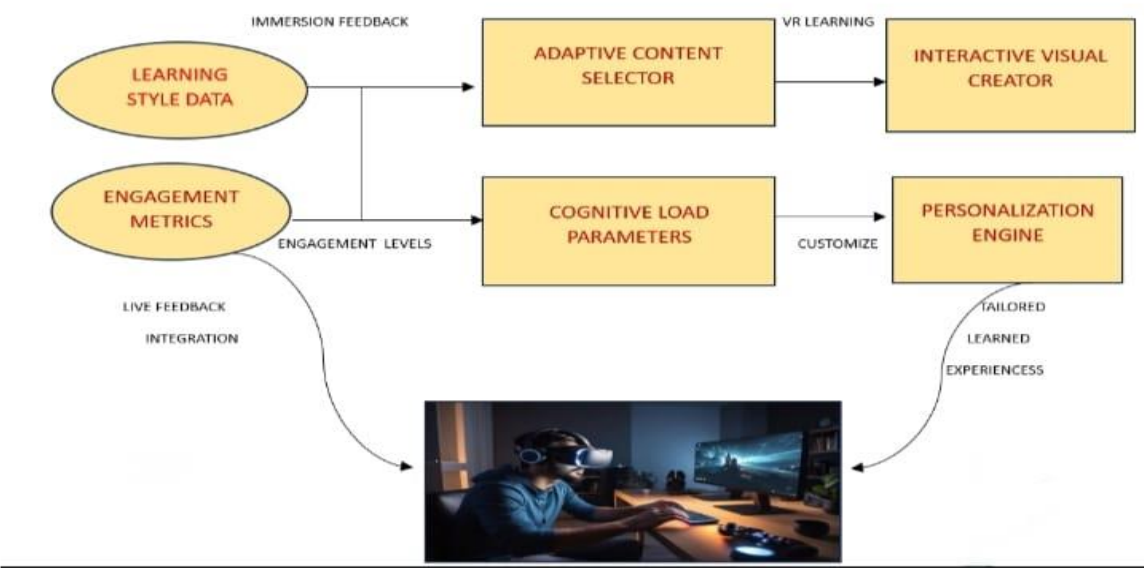

Figure 1. Personalized VR Learning Model Framework

B. Emotion-Driven Adaptive Learning

The integration of Virtual Reality (VR) and biometric technologies presents a groundbreaking approach to enhancing student engagement in virtual classrooms. This research utilizes a custom-designed Convolutional Neural Network (CNN) model embedded in VR headsets, which are equipped with discreet biometric sensors, such as cameras, to analyze facial expressions. By focusing on the lower half of the face, the system overcomes the challenges posed by VR headsets that obscure parts of the user's face. The model identifies emotions like boredom, neutrality, confusion, and happiness, providing teachers with real-time insights through an emotional dashboard (Pande & Johnson, 2022).

This feedback enables educators to adjust their teaching strategies in real-time, ensuring lessons remain engaging and effective. Additionally, the system generates detailed reports after each session, providing a broader understanding of students' emotional responses and enabling further improvements in teaching. With this innovative approach, the technology fosters a more adaptive and empathetic learning environment while maintaining student privacy by avoiding the storage of raw facial data. This framework represents a significant step toward creating emotionally responsive and immersive virtual educational outcomes (Shomoye, 2024).

A more advanced application of emotion-driven technology is implemented in a VR-based online examination framework, which dynamically adapts the assessment environment to students' emotional and behavioral states. The system responds to stress, anxiety, or disengagement by adjusting question difficulty, pausing the exam, or providing supportive prompts using biometric inputs such as facial expressions and physiological signals. These interventions aim to preserve

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student focus and reduce cognitive overload. The underlying artificial intelligence models used for emotion recognition and behavioral assessment include CNNs, RNNs, and SVMs, as described in Table 1.

Table 1. AI Models for Emotion and Behavior Adaptation

Category	AI Model / Method	Core Function	Application in the System
Emotion Detection	CNN (Convolutional Neural Network)	Detects facial emotions from the lower half of the face	Identifies learner emotions even when headsets obscure upper facial regions
Emotion Detection	RNN (Recurrent Neural Network)	Analyzes temporal physiological signals like heart rate variability and GSR	Continuously monitors emotional states throughout the exam session.
Emotion Detection	SVM (Support Vector Machine)	Classifies multimodal emotional input into unified emotion scores	Integrates visual, audio, and sensor data to classify learner affect
Behavior Recognition	HMM (Hidden Markov Model)	Detects sequential behavioral patterns	Distinguishes natural distractions from potential cheating attempts
Behavior Recognition	Bayesian Network	Provides probabilistic inference between normal and suspicious behavior	Evaluates behavior contextually to ensure fairness in interpretation
Behavior Recognition	NLP (Natural Language Processing)	Analyzes verbal responses during clarification prompts	Determines student intent and confidence based on spoken responses

To ensure fairness, a contextual behavior analysis system continuously monitors patterns, including eye movement, posture, and voice. Context-aware AI models distinguish between accidental and suspicious behaviors, prompting the student only when necessary, while high-risk incidents are escalated for manual review. Technical implementations using Hidden Markov Models (HMMs) and Bayesian Networks are also detailed in Table 1. In support of ethical transparency, a hybrid proctoring model combines automated detection with human supervision—allowing machines to handle routine anomalies and humans to intervene in critical cases.

Gamification is integrated into the exam system through a points-based integrity monitoring mechanism. Students earn rewards for attentiveness and ethical conduct, with real-time scoring managed by reinforcement learning models and Graph Neural Networks (GNNs), detailed in Table 2. The framework also introduces a collaborative accountability model, wherein students are grouped into virtual spaces with a shared integrity score. Each student's actions impact the group's outcome, encouraging mutual responsibility and fostering ethical awareness during remote assessments.

This feedback enables educators to adjust their teaching strategies in real-time, ensuring lessons remain engaging and effective. Additionally, the system generates detailed reports after each session, providing a broader understanding of students' emotional responses and enabling further improvements in teaching. With this innovative approach, the technology fosters a more adaptive and empathetic learning environment while maintaining student privacy by avoiding the storage of raw facial data. This framework represents a significant step toward creating emotionally responsive and immersive virtual educational outcomes (Shomoye, 2024).

Table 2. Gamification and Group Integrity Models

Function / Feature	AI Technique or Architecture	Purpose	Application in the VR Assessment System
Real-Time Ethical Scoring	Reinforcement Learning	Encourages honesty and focus by rewarding positive behavior	Students earn points for maintaining attentiveness and avoiding dishonest actions
Real-Time Ethical Scoring	GNN (Graph Neural Network)	Manages complex interdependencies among group behaviors	Dynamically adjusts group integrity scores based on collective student behavior
Social Accountability	Group Accountability Framework	Promotes mutual responsibility among students	Each student's action influences the overall score and outcome of their virtual exam group.
Adaptive Collaboration Engine	Hybrid Logic (Rule-based + RL)	Balances fairness and adaptation using reward-penalty mechanisms	Provides real-time feedback and incentives for collaborative and ethical behavior

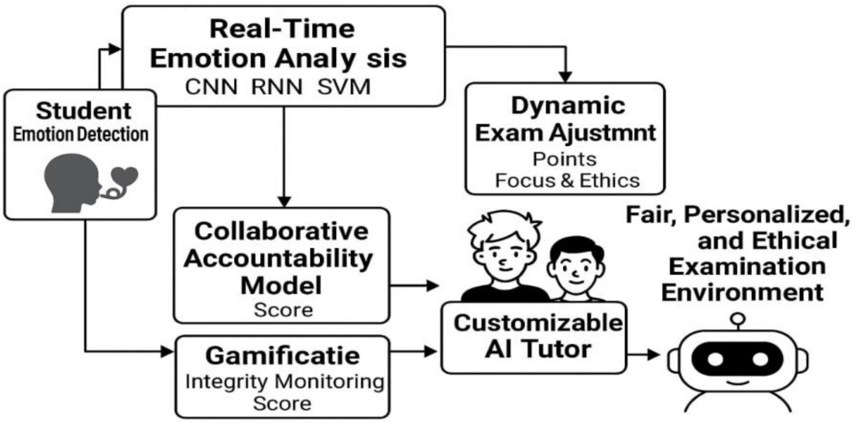

Figure 2. Emotion-Adaptive Online Exam Flow

C. Adaptive VR Personalization Techniques

Personalized learning pathways in VR environments are enhanced through several adaptive strategies. One such approach enables learners to directly interact with virtual objects by adjusting their properties and observing them from various perspectives, promoting an engaging and hands-on educational experience. For example, in the context of molecular visualization, VR enables students to explore molecular structures, allowing them to manipulate and examine these models from multiple angles, thereby simplifying complex biological concepts (García-Bonete et al., 2022). In a similar application, students used VR to modify electric field vectors and observe their behavior from different viewpoints, thereby enhancing their understanding of electrostatic concepts (Porter et al., 2023). A virtual solar system also allowed learners to alter the passage of time and perspectives, helping them better comprehend phenomena like lunar phases (Madden et

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al., 2022). These implementations enable learners to engage at their own pace and according to their preferences.

Another method is autonomous navigation, where learners navigate through virtual environments as they would in the real world, with the freedom to move independently without following predefined routes. In one study, students were introduced to an immersive VR system that enabled them to teleport and explore freely, resulting in increased engagement and more personalized educational outcomes (Pirker et al., 2023). By allowing students to set their own pace, this type of navigation promotes independence and encourages curiosity during the learning process (Rao & Li, 2021).

Adaptive VR systems also enable tailored feedback mechanisms. Effective learning depends on timely and relevant feedback, and VR facilitates personalized, immediate responses to learners' actions, enabling them to track their progress and focus on areas that require attention (Broetje & Van Ginkel, 2021). Research on instant feedback cues has included visual and auditory elements, such as changes in color and sound, when learners interact with virtual objects, guiding their understanding as they work (Parmer et al., 2022). Personalized reports on aspects such as pitch and pacing during oral presentations also allow students to focus on specific areas for improvement (Broetje & Van Ginkel, 2021). These methods ensure that feedback is relevant and targeted, offering more specific guidance than traditional, generic feedback.

Assisted learning further personalizes the VR experience. Virtual environments can offer step-by-step guidance to learners, ranging from simple instructions to more complex support from virtual agents, helping students through tasks. In one example, a virtual drone guided students during environmental biology tasks, keeping them engaged and on track (Pande et al., 2022). Instructional support has also been implemented through VR systems that guide students in assembling virtual components, offering both written and auditory instructions to improve their practical skills (Seigniorial et al., 2023). This type of assistance simplifies complex tasks, making learning more approachable and accessible.

Additional personalization strategies continue to enrich VR learning. Eye-tracking technology enables learners to interact with objects or navigate through virtual spaces by simply focusing their gaze, resulting in a more intuitive educational experience. Motion tracking adjusts the VR experience according to the user's physical movements, thereby enhancing immersion and engagement. Moreover, some VR applications allow learners to design their own environments or objects, fostering a sense of ownership and deeper involvement in the learning process (Marougkas et al., 2023).

Another innovative technique involves the use of customized AI tutors. As AI tutors gain popularity in today's educational landscape, an exciting concept is to allow students to fully customize their AI tutor's appearance. This customization could include transforming the tutor into a favorite celebrity, cricketer, anime character, or any cartoon figure the student prefers. Having a tutor in the form of a beloved figure can make the learning process more engaging and enjoyable, especially for younger students. By incorporating familiar faces or characters, the educational outcome becomes more entertaining, motivating, and personal, encouraging students to stay focused and connected with the material in a fun and relatable way. This concept is illustrated in Figure 3.

Figure 3. Customized Ai Tutors

Finally, VR can also be used to detect student emotions in real time, such as nervousness, which may indicate discomfort or anxiety. In an online live class setting, if a student appears nervous, the system can prompt them to explain the cause—whether it's a genuine reason like needing to use the restroom or an emergency. If the student provides a valid response, the system ensures the warning is appropriately handled. However, if the nervousness is determined to be linked to potential cheating behavior, a report will be automatically sent to the teacher for further action. This system helps ensure both empathy and integrity within the virtual classroom. A visual example of this application is shown in Figure 4.

Figure 4. Online Learning Alerts

D. Gaps and Limitations in Current Research

Over-Immersion: Cognitive strain may arise from high sensory fidelity. Scalability: Due to resource requirements, it is challenging to widely implement. Real-World Disconnect: Challenges in applying VR-learned skills to real-world situations. Customization Complexity: It still requires a significant amount of resources to modify VR systems to suit individual tastes. Over-reliance on fixed learning preference models may not be appropriate in all situations.

III. RESEARCH METHOD

A. Participants and Context

A total of 77 high school students (22 males, 55 females) from three Grade 11 classes in Taiwan participated in this study. The participants, aged 15 to 18 years (mean age = 16.1), were selected to examine how learning styles, cognitive load, and sense of presence impacted learning outcomes in a virtual reality (VR) educational setting. These students were enrolled in general science classes, making them suitable candidates for testing immersive STEM-related content. Their prior exposure to VR was minimal, ensuring that the results reflected authentic experiences of first-time users.

B. Methods and Methodology

The experiment followed an intervention-based approach, where participants interacted with "The Body Cell," a VR program that provides a 3D simulation of human blood cells and organelles. The research process involved three stages. Pre-Treatment: Students first completed the Index of Learning Styles (ILS) questionnaire, derived from the Felder-Silverman Learning Style Model (FSLSM), which helped identify individual learning preferences in information processing and understanding. Treatment: In this phase, students received training on using the VR equipment, including head-mounted displays and handheld controllers. They spent 30 minutes exploring the virtual bloodstream, manipulating 3D models, and studying the structure and functions of cells. Post-Treatment: After completing the VR session, students took a knowledge test to measure their comprehension. Additionally, they filled out questionnaires to assess their sense of presence, cognitive load, and satisfaction with the educational outcomes.

C. *Instruments and Analytical Techniques*

Various validated tools and statistical techniques were employed throughout the study. ILS Questionnaire: Used to assess the students' preferred learning styles. Sense of Presence Questionnaire: Measured students' levels of immersion, sensory fidelity, and the overall quality of the VR environment. Cognitive Load Questionnaire: Gauged the mental effort required and the perceived difficulty of the task. Learning Satisfaction Survey: Evaluated students' overall satisfaction with the VR educational outcomes. Knowledge Test: Consisted of 12 questions that tested knowledge on topics related to blood cells and their functions. For data analysis, the researchers employed several statistical techniques. Exploratory Factor Analysis (EFA): Used to ensure the reliability of the questionnaires. Item Response Theory (IRT): Applied to validate the accuracy of the measurement scales. Quantile Regression: Used to examine the predictive relationships between various variables. Mann-Whitney U Test: Employed to identify differences in cognitive load and learning outcomes across the different learning styles.

D. Execution and Process

Each participant completed the experiment individually to enhance focus and engagement. Using handheld controllers, students explored and interacted with the virtual world, which allowed them to visually and physically engage with cell structures. This setup was designed to minimize external distractions and ensure a consistent user experience across all participants. The immersive and hands-on nature of the experience aimed to address both cognitive and emotional learning aspects.

E. *Findings and Key Results*

The study's main findings include several key insights. Learning Styles: Learning outcomes were not directly influenced by learning styles. However, students' learning styles affected their cognitive load and sense of presence. Visual learners felt more immersed in the experience, while reflective learners reported experiencing higher mental effort. Sense of Presence and Cognitive Load: Greater immersion and sensory fidelity were associated with higher levels of satisfaction. However, high cognitive load was found to negatively affect performance. Learning Outcomes: Overall, students found the VR experience enjoyable; however, those who were highly engaged sometimes experienced cognitive overload, which hindered their ability to retain information.

F. *Study Implications*

The findings suggest that VR can be an effective tool for enhancing engagement and satisfaction across various learning styles, provided cognitive load is properly managed. The study suggests that VR environments should be tailored to accommodate the unique learning preferences of individual students, thereby finding an optimal balance between immersion and cognitive complexity, and thereby maximizing educational benefits (Huang et al., 2019). These insights offer valuable guidance for educators and instructional designers seeking to integrate immersive technologies into diverse classroom settings. By aligning VR features with pedagogical goals and individual learner profiles, the effectiveness and scalability of technology-enhanced education can be further improved.

IV. RESULT

The Results section must present the research findings clearly, objectively, and systematically, without interpretation or discussion. Authors should provide a logical and coherent description of the outcomes derived from the analysis, aligned with the research objectives and hypotheses. Data should be organized and presented in a manner that highlights key patterns, trends, or relationships. Whenever possible, results should be summarized in a way that facilitates understanding, using both narrative text and appropriate visual aids. Comparative analyses, statistical outputs, or significant findings must be reported accurately, ensuring that the presentation of results remains distinct from their interpretation or implications, which are discussed in the following section.

All figures, tables, and mathematical formulas must be explicitly mentioned within the narrative text and integrated into the flow of the discussion. They must be numbered sequentially (e.g., Figure 1, Table 2, Equation 3) according to their first appearance. Each figure or table must include a descriptive title and, if necessary, a brief explanatory note or legend to aid comprehension. Images must meet a minimum resolution of 300 dpi to ensure clarity and quality in publication. Mathematical formulas must be formatted appropriately, and each symbol or variable should be clearly defined upon first introduction. Visual elements should be used to enhance, not merely illustrate, the text, ensuring that the findings are both accessible and understandable to the reader.

A. Findings Related to Learning Styles and Presence

The study explores how immersion, cognitive load, and learning preferences affect outcomes in AI-supported virtual education settings. The key findings are as follows: Learning Satisfaction: Students who felt more engaged, immersed, and invested cognitive effort in the VR tasks reported greater satisfaction. Factors such as involvement, immersion, and sensory fidelity played a positive role in improving their educational outcomes. Knowledge Test Performance: Somewhat unexpectedly, students who experienced higher immersion, perceived better interface quality, or exerted greater mental effort performed worse on knowledge tests. This suggests that excessive engagement or cognitive load might hinder effective learning, even when students report higher satisfaction with the learning experience.

Learning Style Variations were also evident in the results. Cognitive Effort: Reflective learners, who process information more carefully, demonstrated higher mental effort compared to active learners, indicating deeper engagement with the material. Immersion: Visual learners, who prefer images and visual aids, experienced a stronger sense of immersion than verbal learners, who favor text-based information. These variations reveal that individual learning preferences shape how students interact with and respond to VR environments. In summary, while VR can enhance engagement and learning satisfaction, excessive cognitive strain may reduce knowledge retention (Huang et al., 2019).

B. Impact of Cognitive Load

The experiment showed that learning styles influenced cognitive load and sense of presence but not directly learning outcomes. Visual learners felt more immersed, while reflective learners experienced higher cognitive load. A strong sense of presence improved engagement and satisfaction, although excessive immersion sometimes caused cognitive overload, which reduced retention. Active exploration in the VR environment enhanced understanding of cell structures, but a balance between immersion and cognitive demands was crucial for optimal performance. Overall, the study emphasized the importance of managing cognitive load to maximize the benefits of VR-based learning.

C. Adaptive Logic Conditions

The adaptive logic condition describes two approaches for customizing VR training: fixed and adaptive. The fixed method determines the initial training settings using baseline performance and self-efficacy, with difficulty increasing at a steady rate throughout the sessions. In contrast, the adaptive method adjusts the training focus—such as prioritizing speed or accuracy—and modifies task difficulty based on the participant's performance in previous trials. This dynamic approach ensures that the training remains tailored to the individual's developing abilities and confidence, aiming to boost engagement and optimize the overall educational outcomes (Lui et al, 2025).

D. Adaptive VR Training

This study further explores the opportunities and limitations of adaptive VR training in enhancing performance and facilitating the transfer of skills to real-world scenarios. While VR training proves highly effective within simulated environments, the generalization of these skills to real-life contexts remains inconsistent. This highlights the need for VR training systems that more accurately replicate real-world conditions to enhance transferability. Adaptive training dynamically adjusts the learning experience in real-time based on user performance and confidence, providing a more engaging and personalized educational process. However, limitations still exist, including a potential disconnect between VR outcomes and real-world applicability—especially when training focuses solely on specific elements, such as speed or accuracy. The study suggests further refinements, including the use of more effective feedback mechanisms and physiological indicators, to enhance the effectiveness of adaptive systems. These findings support the promise of adaptive VR in skill development, while highlighting the importance of thoughtful design for greater real-world relevance (Lui et al., 2025).

V. DISCUSSION

The findings of this research indicate that interactive virtual reality (VR) environments can enhance students' satisfaction and engagement, particularly among visual and reflective learners. This is consistent with prior research emphasizing the significance of multimodal interaction in adaptive VR learning (Lui et al., 2025; García-Bonete et al., 2022). However, the discovery that increased immersion and sensory detail can potentially lead to increased cognitive load, and thus potentially hinder performance, introduces a nuanced understanding. Whereas earlier studies have essentially focused on motivational benefits of VR (Nguyen & Chen, 2023), the results reveal that without stringent control of cognitive load, such benefits may not manifest as measurable indicators of learning. The discrepancy between perceived satisfaction and genuine test performance can stem from the difficulty of reconciling realism with the mental processing requirements of VR systems (Marougkas et al., 2023).

Several limitations to the present research must be acknowledged to put these findings into perspective. Most importantly, the absence of a non-VR control group precludes direct comparison and may restrict generalizability. The sample consisted of 77 students from one region, which limited further extrapolation. Additionally, learning outcomes were assessed immediately after exposure to VR, with retention and transfer of skills after an unspecified period of time. Reliance on self-report scales of presence and cognitive load also has the potential to introduce bias. Lastly, the research was conducted with specific hardware and a commercial VR platform ("The Body Cell"), which will impact replicability on other platforms or in larger academic environments. Despite these limitations, findings offer valuable insights into the interactions between immersion, cognitive burden, and individualized learning. This highlights the importance of developing a VR experience that is adaptive and pedagogically justifiable.

VI. CONCLUSION AND RECOMMENDATION

This study concludes that adaptive interactive virtual reality (VR) learning environments, when designed with adaptation features, have great potential to enhance student motivation and satisfaction with different learning styles. Visual and reflective learners particularly benefit from immersive engagement; however, a higher cognitive load can lower actual learning performance. While the use of VR supports greater interaction and personalized experiences, the findings also show a primary balance between sensory interaction and cognitive capacity. The study contributes to the growing body of literature by reiterating the importance of awareness of cognitive load in VR learning and highlighting the variance in learning experiences according to individual preferences.

Later research can overcome some of the constraints of the present study by employing bigger, more diverse samples across different educational settings and also including a control group involving traditional or non-VR instruction for comparison purposes. The long-term retention and generalizability of skills acquired through VR require investigation through longitudinal studies. More access to the closed VR system ("Space Cell" and "The Body Cell") and testing on its compatibility with various hardware platforms would increase replicability and external validation. In addition, combining objective physiological measures with self-reports would increase the validity of presence and cognitive load measures. These channels will continue to promote adaptive VR systems into broader and more efficient educational applications.

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