Exploring the Educational Potential of VR: Immersive vs. Non-Immersive VR in Virtual Space Learning

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ABSTRACT

This study explores the impact of Virtual Reality (VR) in architectural education at Atma Jaya Yogyakarta University, focusing on the differences between immersive and non-immersive VR experiences. Two groups of architecture students participated in the study: one group used VR headsets, while the other engaged with non-immersive virtual environments. Both groups completed a User Experience Questionnaire (UEQ), and their responses were analysed using the Mann-Whitney U test. The study found that students using VR headsets reported significantly higher engagement, satisfaction, and overall positive experience than non-immersive methods. These findings suggest that immersive VR has more potential to enhance student learning experiences in architectural education, providing valuable insights for developing practical digital learning tools and strategies.

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1. INTRODUCTION

1.1. Background

The implementation of the Merdeka Belajar policy during the Covid-19 pandemic has necessitated a shift towards online learning. However, research [1][2] suggests this system is ineffective. To enhance the effectiveness of online education, virtual reality (VR) technology can be utilised [3][4][5]. Research has shown that VR can complement traditional learning tools, particularly in architectural education, by providing immersive environments that enhance understanding of complex concepts such as fire safety design [6].

Virtual Reality (VR) technology is an innovation that allows for the simulation of real objects through a computer, creating a three-dimensional (3D) environment that makes users feel physically involved [7][8]. Recognising the potential of VR, this study aims to explore how VR environments with virtual experiences can be implemented as an educational media tool in higher education. Higher education institutions are increasingly adopting advanced technologies to enhance educational experiences and foster innovation among students. Virtual Reality (VR) is one such technology that has demonstrated significant potential in transforming educational practices. While universities such as UM Surabaya, Institut Sains dan Teknologi

Terpadu Surabaya (ISTTS), Unika Atma Jaya, and Universitas Petra have begun exploring VR's capabilities, its application in architectural education, particularly in virtual space learning, remains underutilised.

A critical observation from recent data at Atma Jaya Yogyakarta University (UAJY) highlights students' uneven use of virtual spaces. As depicted in Table 1, different campuses show varying levels of engagement with virtual spaces, with Campus 2 leading in overall visits (1,600 visits to the campus area) and Campus 1 trailing with fewer visits to classroom and discussion room spaces. This disparity raises concerns about the effectiveness and accessibility of VR tools in promoting immersive learning, particularly in architecture, where spatial understanding and interaction are crucial.

The current use of VR at UAJY and similar institutions reveals a gap between the availability of technology and its actual implementation in architectural education. This study addresses this issue by exploring the challenges and opportunities associated with VR in architecture, focusing on the differences between immersive and non-immersive VR experiences. By examining student engagement data and the practical application of VR, this research aims to provide insights into how VR can be more effectively integrated into architectural curricula to enhance student learning outcomes.

In alignment with UAJY's mission to prepare students for the digital era, this research will contribute to developing more adaptive and innovative educational practices. It emphasises the need for a strategic approach to VR integration, ensuring that the technology enhances the learning experience and aligns with the specific needs of architectural education.

Table 1. Table of Virtual Space Visits at UAJY as of October 24, 2023.

Campus	Room	Number of Visits
Campus 1	Campus	702
	Classroom	143
	Discussion room	59
Campus 2	Campus	1600
	Classroom	424
	Discussion room	64
Campus 3	Campus	1500
	Classroom	265
	Discussion room	146
Campus 4	Campus	592
	Classroom	137
	Discussion room	279

Alongside the launch of the RVKUAJY program, it should be understood that the investment in virtual reality (VR) education technology represents a significant step for Atma Jaya Yogyakarta University (UAJY) in enhancing the quality of learning and strengthening the interaction between students and lecturers. However, despite expecting this investment to bring positive benefits, initial observations indicate that students have not utilised the RVKUAJY program optimally.

Based on data from the Spatial.io platform, there is a significant difference in the number of visits between campuses. With a total of 11,106 students, Campus 2 has the highest number of visits (1600 visits), while Campus 1, Campus 3, and Campus 4 show lower visitation rates (see Figure 1). These findings indicate the need for a thorough evaluation of the use of virtual spaces for online learning at UAJY to understand student preferences and ensure future learning effectiveness. Comprehensive statistical data is expected to enhance the quality of online education at UAJY.

1.2. Enhancement of Online Learning

In efforts to improve the effectiveness of online learning systems, the utilisation of virtual reality (VR) technology has been identified as a promising solution, as demonstrated by several previous studies [9][10]. The findings of these studies consistently confirm that the use of VR technology can significantly enhance the learning experience and the level of student participation [11][12]. Furthermore, the implementation of VR technology also has tremendous potential to contribute significantly to improving understanding and optimising the learning process. With its clear advantages, VR technology can provide a much better and more effective learning experience than traditional learning methods such as books or videos [13]. Therefore, VR technology can be considered a strategic step to bring about significant positive changes in online learning.

1.3. Virtual Space as a Learning Environment

Virtual Reality (VR) generally refers to futuristic science fiction concepts and cutting-edge hardware. However, VR is closely related to the neurocognitive processes within the human brain that do not require special equipment. Humans can experience alternative realities through imagination, including thoughts, fantasies, and cognitive processes that impact the development of conceptual and creative thinking [14]. Alongside the evolution of human civilisation since ancient times, the development of virtual worlds has become an integral aspect of human experience. As a practitioner or academician in the field of technology, having a sharp and deep understanding of the history and evolution of virtual media is crucial for developing a creative future vision and devising innovative solutions to address complex issues through immersive technology. This profound knowledge is a vital foundation for applying the planned Metaverse concept [15][16].

The application of online learning systems in the Metaverse environment is believed to overcome limitations in social connectivity and enrich informal learning experiences. With the presence of features such as telepresence, avatar body language, and the ability to express emotions and facial expressions realistically, virtual meetings are expected to have effectiveness equivalent to face-to-face interactions, thus providing an equally engaging experience as physical presence in a classroom.

1.4. Virtual World and Immersive Space in Learning

Virtual Reality or Virtual Space is unique compared to other media technologies due to its absorbing technical nature and impact on users [17]. Although there are differences in terminology, many studies use the term immersion to describe technical system features and the term presence to refer to perceived psychological responses when using immersive systems. Immersion implies that the system blocks the user's sensory perception of the physical world and replaces it with a flow of digital audiovisual content that reacts to user actions in a way that mimics physical reality (e.g., if users move their hands, their avatar hands replicate those movements in real-time).

Presence has been defined as the feeling of "being there," physically placed within the virtual environment [18]. The sense of presence involves perceptual illusions without mediation that make users feel - and often react to - the VR environment as if it were real, even though they know it isn't . Instead of treating presence as a singular concept, some studies often distinguish several types of presence, including spatial presence, embodiment or self-presence, and social presence. Spatial presence refers to feeling physically inside the virtual environment, embodiment (or self-presence) describes the user's sensation that their virtual avatar body is their actual body, and social presence refers to the perception of being in a place and connected with others.

1.5. Perception of Virtual Space

Immersion describes a user's engagement in a virtual environment where their awareness of time and the real world is often disrupted, thus providing a sense of 'being' in that task environment [19]. Define this term as the perception of being physically present in a non-physical world through the user's VR system-created images, sounds, or other stimuli,' so that participants feel as though they are genuine 'there.'

The concept of perception itself is the mental process by which individuals organise, interpret, and give meaning to the information received through their senses. Stimuli from the environment are converted into neural signals processed in the brain and analysed based on individual knowledge and experiences. This affects how we respond to situations, make decisions, and interact with people and the environment, while cultural influences, backgrounds, and personal experiences can cause differences in perception between individuals.

In virtual space learning, it is essential to understand that several challenges must be overcome regarding achieving realistic visual perception. As described [20], the difference between perception in the real world and the virtual world, especially in estimating size and distance, is one of the main problems to be addressed. The paper discusses several approaches to overcome these challenges, including interpupillary distance adjustment and pupil position. Through these approaches, the learning experience in virtual space can be enhanced and made as close to reality as possible.

2. RESEARCH METHOD

This research begins by understanding the background underlying the increased use of online learning in education. In the initial phase, an in-depth analysis will be conducted regarding the potential and challenges of online learning, as well as existing case studies within the scope of architecture. Subsequently, the research objectives will focus on enhancing online education's effectiveness by utilising virtual space and VR technology. Once the initial research is completed, the next step is to design a survey to measure the satisfaction levels of architecture students with the online learning experiences they have encountered.

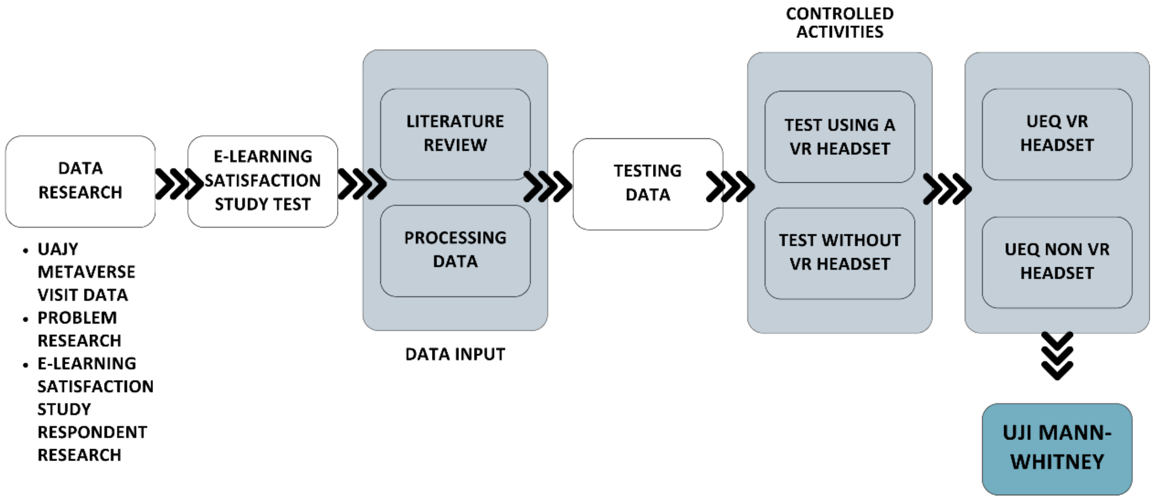

Figure 1. Research Framework Flow

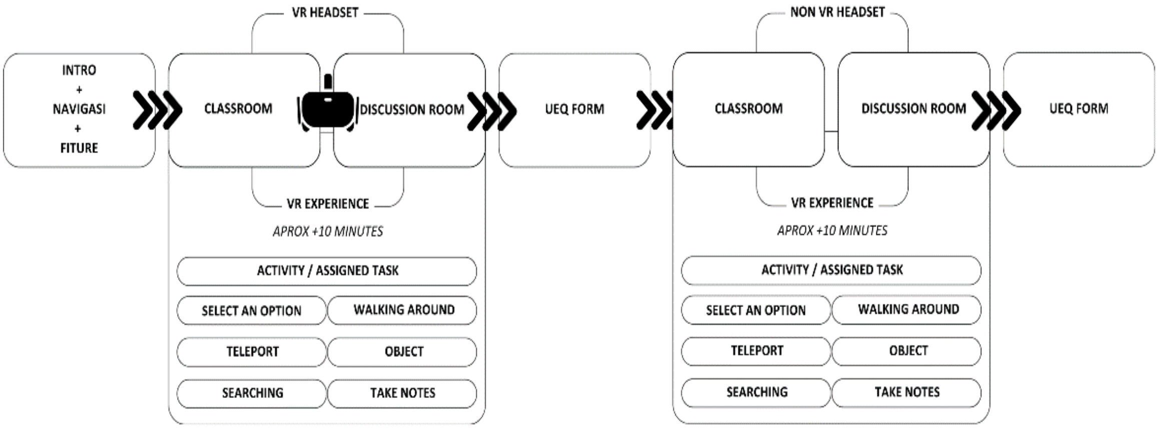

Figure 2. Data Collection Process

The collected data will be processed to gain a deeper understanding of the needs and preferences of students. Additionally, relevant literature will be sought to find possible solutions that could enhance the quality of online learning by leveraging virtual space. The trial implementation will involve two groups, one using VR headsets and one without, to measure the impact on the learning experience. The results of both treatments will be analysed, and virtual space usage data will be evaluated using the User Experience Questionnaire (UEQ) and Mann-Whitney tests conducted to compare the experimental groups. The research will conclude by summarising the data analysis results, revealing findings, and providing recommendations for further research and implications of this study.

The proposed research method aims to analyse the effectiveness of the Virtual Campus Space at UAJY for architecture students in their online learning experience in virtual spaces, comparing the usage of VR headsets and without VR headsets. This research employs the UEQ (User Experience Questionnaire) method to measure students' responses to this experience. Furthermore, the difference in perception between these two conditions will be tested using the Mann-Whitney test in the experimental class with the assistance of SPSS statistical software. Here is a more detailed explanation of this methodology:

2.1. UEQ (User Experience Questionnaire)

User Experience Questionnaire is a measurement tool that has been proven to be valid and reliable for measuring user experience with a specific system or product. In this context, UEQ will be used to evaluate the knowledge of architecture students during online lectures in virtual spaces, both with and without VR headsets.

Quantitative data will utilise the UEQ method. The User Experience Questionnaire (UEQ) is one of the usability testing methods to collect quantitative data on users' impressions of their experience with a product. The UEQ consists of six scales with a total of 26 items, including:

- Attractiveness: Overall impression generated by a product, whether users like the virtual reality product or not.
- Perspicuity: The level of ease a product provides a familiar impression to virtual reality users.
- Efficiency: How efficiently virtual reality users can achieve their goals without unnecessary actions.
- Dependability: Users can control virtual reality interactions using virtual reality products.
- Stimulation: How well virtual reality products can create a sense of pleasure and motivate users.
- Novelty: A virtual reality product's innovation and creativity level.

2.2. Research Design

This study employs an experimental quantitative design. Students will be given the experience of using virtual space with VR headsets and without VR headsets with the same respondents in each test group, resulting in two treatment groups. Each group will be tested using a UEQ questionnaire adapted to the research context.

2.3. Participants

The participants of this study consist of architecture students at Atma Jaya Yogyakarta University who are involved in online lectures in virtual spaces. Participants will be randomly selected to ensure a fair representation of the architecture student population. Referring to the research [21] to investigate the role of different visual cues (images and texts) on user performance when manually assembling in a VR setting (VIVE Headset) and non-immersive environment (desktop), 10 respondents are needed for the Mann-Whitney test, so the responses in this study will be conducted with the same 10 respondents in 2 control groups. A total of 10 participants will undergo UEQ testing twice for the virtual space experience with and without VR headsets.

2.4. Data Collection

The collected data includes responses from the UEQ questionnaire measuring aspects such as satisfaction, attractiveness, efficiency, stimulation, relatedness, and identity towards the online learning experience in virtual spaces, both with and without VR headsets.

2.5. Data Analysis

After data collection, the data will be analysed using the Mann-Whitney test to evaluate significant differences between the two treatment groups. This analysis will be conducted with the assistance of statistical software SPSS to ensure the accuracy and validity of the analysis. There is a difference between the experimental and control classes in statistical analysis using the Mann-Whitney test in statistical software like SPSS.

a. Experimental Group
   The experimental class refers to the group of subjects or samples given specific treatment or intervention in the research context. In an experiment, this group usually receives treatment or variables being tested for their effects. For example, in an educational context, the experimental group may receive a new teaching method or specific intervention being tested.
b. Control Group
   The control class refers to the group of subjects or samples that do not receive the same treatment or intervention as the experimental group. This control group aims to provide a comparison or

reference point for the experimental group to measure the effectiveness of the treatment or variables being tested. This control group helps researchers evaluate whether the treatment or other unrelated factors cause the observed changes in the experimental group.

In the context of the Mann-Whitney test, the experimental class compares user experiences using the User Experience Questionnaire (UEQ) under two conditions: first, when using VR headsets; second, when not using VR headsets.

3. RESULTS AND DISCUSSION

The implementation of Virtual Reality (VR) technology, particularly the use of VR headsets like Oculus, has the potential to impact the user experience within a virtual campus space significantly. This study compares the effects of VR headset usage and non-VR headset/monitoring on user experience in the virtual campus space of Atma Jaya Yogyakarta University (UAJY).

Comparative testing of the Virtual Room using a VR headset and without a VR headset was conducted in a follow-up study. The use of VR (Virtual Reality) in RVKUAJY, such as a VR headset like Oculus, has a different impact than a non-VR headset or ordinary monitoring. Therefore, the Mann-Whitney U test was used to determine whether there is a difference between the VR-headset user group and the non-V VR-headset (monitoring) user group regarding its impact on the experience in the UAJY Campus Virtual Room. In the Mann-Whitney U test, 10 respondents were used as a comparison for the use of the Immersive and Non-Immersive campus Virtual Room.

Table 2. Data Input in the Mann-Whitney Test

Number	UEQ Result		Code	
	Monitoring (non-VR Headset)	Oculus (VR Headset)	A	B
R1	101	101	1	2
R2	107	103	1	2
R3	122	129	1	2
R4	114	102	1	2
R5	114	97	1	2
R6	129	96	1	2
R7	110	102	1	2
R8	104	100	1	2
R9	109	176	1	2
R10	102	104	1	2
R11	113	101	1	2
R12	109	102	1	2

The Mann-Whitney U, a non-parametric statistical test, compares independent groups. Its utility lies in situations where data is not normally distributed or sample sizes are relatively small [22]. This paper outlines combining separate datasets to conduct a Mann-Whitney U test within the SPSS statistical software.

- **Data Preparation:** The initial step ensures both datasets share identical names for the test variable (the variable targeted for group comparison) and the grouping variable (representing the factor differentiating the two groups).
- **Data Combination: Both** datasets are initially imported into the SPSS environment. The next step is Grouping Variable Consolidation. In this stage, A unified grouping variable must be constructed if datasets contain separate columns for the grouping variable. This variable should assign a consistent code (e.g., "A" or "B") to all observations within one dataset and a distinct code (e.g., "B" or "A") to all observations from the other dataset.

3.1. Mean Rank Comparison

Observe the difference in mean rank between the VR headset user group and the non-VR headset/monitoring user group. A higher value indicates a superior group in terms of its impact on the virtual campus experience.

3.2. Sum of Ranks Comparison

Compare the total ranks between the two groups. A higher total rank indicates a more dominant group in the virtual space experience.

Table 3. Ranks Result from Mann-Whitney Test

Test Statistics	UEQ Result
Mann-Whitney U	33.500
Wilcoxon W	111.500
Z	-2.232
Asymp. Sig. (2-tailed)	.026
Exact Sig. [2*(1-tailed Sig.)]	.024[b]

3.3. Mann-Whitney U Interpretation

Interpret the U value. A lower value suggests a significant difference between the VR headset user group and the non-VR headset/monitoring user group.

a. **Asymp. Sig Interpretation:** A significance value less than the alpha level (0.05) indicates a significant difference between the two groups.
b. **Exact Sig Interpretation:** The research hypothesis tested in this study was "There is a significant difference in the perception of using monitoring tests compared to VR-Headset tests in the virtual campus space." The mean rank analysis revealed that the Monitoring group had a higher mean rank (15.7) than the VR-Headset group (9.29). The rank indicates that, on average, participants in the Monitoring group tended to have higher rankings than participants in the VR-Headset group.

The total ranks for the Monitoring group (188.50) were higher than those for the VR-Headset group (111.50). The rank result suggests that the data for the Monitoring group had higher overall rankings. The Mann-Whitney U value of 33.500 was relatively low, indicating a significant difference between the two groups. This U value was calculated by comparing ranks between the two groups.

Table 4. Ranks Result from Mann-Whitney Test

Ranks				
	CODE	**N**	**Mean Rank**	**Sum of Ranks**
UEQ Result	Non-Vr Headset	12	15.71	188.50
	Vr Headset	12	9.29	111.50
	Total	24		

The Asymp. The Sig (2-tailed) value of 0.026 was lower than the commonly used alpha level of 0.05. Therefore, the null hypothesis (no difference) could be rejected, and it could be concluded that there was a significant difference between the Monitoring Test and VR-Headset Test groups. The Exact Sig [2*(1-tailed sig.)] value provided additional information about significance. A value lower than alpha indicated that the difference between the two groups was statistically significant. In summary, the data analysis supported the research hypothesis that there was a significant difference in the perception of using monitoring tests compared to VR headset tests in the virtual campus space. The Monitoring group tended to have higher rankings and overall data significance, indicating a more positive perception of the monitoring test than the VR-Headset test.

4. CONCLUSION

The Mann-Whitney test results indicate a statistically significant difference between the Monitoring and VR-headset groups in the virtual campus space. This finding supports the alternative hypothesis, which posits that there is an effect of using the Monitoring test compared to the VR-headset test in the virtual campus environment.

The higher mean rank and total ranks for the Monitoring group suggest that participants generally had a more positive perception of the Monitoring test than the VR-headset test. Additionally, the low Mann-Whitney U value and the significance value (Asymp. Sig (2-tailed)) below the alpha level (0.05) further reinforce the conclusion that there is a significant difference between the two groups.

Based on these findings, using the monitoring test has a more positive impact on user experience in the virtual campus space than using a VR headset. This positive impact could be due to various factors, such as familiarity with the Monitoring test format, the perceived effectiveness of the test in assessing knowledge, or the comfort level of participants using a traditional testing method. This could be due to various factors, such as familiarity with the monitoring test format, the perceived effectiveness of the test in assessing knowledge, or the comfort level of participants using a traditional testing method.

Further research is needed to explore the reasons underlying the observed differences and identify potential strategies for optimising Monitoring tests and VR headsets in virtual learning environments.

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