Computer Fraud and Security
ISSN (online): 1873-7056

The Impact of Virtual Reality Technology on Developing Critical Thinking Skills in University Students

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Abstract

This study aims to analyze the impact of Virtual Reality (VR) technology on the development of critical thinking skills in university students. Critical thinking skills have become increasingly crucial in addressing global challenges and the complexities of the professional world, leading to the consideration of innovative learning methods such as VR. This literature review explores various studies examining the effectiveness of VR in creating interactive, immersive, and collaborative learning environments. VR enables students to directly engage with real-world simulations that support analytical abilities, problem-solving, and decision-making. The results indicate that VR has significant potential to enhance critical thinking skills, particularly in situations that require deep analysis and reflection. However, this study also finds that standardized tools to quantitatively measure the impact of VR on critical thinking skills are still limited, and the implementation of VR in educational institutions requires substantial investment in technological infrastructure. Therefore, this study highlights the need for further research to develop more comprehensive evaluation methods and to explore the long-term effects of VR usage in education.

Keywords: Virtual Reality, critical thinking skills, innovative learning

Introduction

Virtual reality (VR) is one of the rapidly evolving technologies that has opened up new opportunities in various fields, including education. In recent years, VR technology has been recognized as a tool with great potential to transform the way students learn and interact with knowledge (Marks & Thomas, 2022). VR allows for the simulation of interactive environments that closely resemble reality, providing a more immersive and in-depth learning experience compared to traditional teaching methods. This can stimulate active student engagement and enhance their understanding of abstract concepts (Mao et al., 2022). One of the key skills that is believed to be improved through the use of VR in education is critical thinking.

Critical thinking is an essential skill for university students. It enables them to analyze information, evaluate arguments, and make decisions based on relevant evidence. In a world that is increasingly complex and

filled with information from various sources, the ability to think critically is crucial for filtering valid and trustworthy information (C.-Y. Chang et al., 2022). However, the challenge in developing critical thinking skills often arises because traditional teaching methods are less effective in encouraging students to engage deeply with the learning material. Most conventional teaching methods focus more on one-way knowledge transfer, where the lecturer delivers information and the students are merely passive recipients (Sultan et al., 2019).

The use of VR technology in education is believed to offer a solution to this challenge. VR creates an immersive learning environment where students not only hear or read information but also experience direct simulations related to the subject matter (Shorey & Ng, 2021). For example, medical students can use VR to practice medical procedures in a safe environment, while engineering students can explore building design and mechanics virtually. The ability to interact with these environments can stimulate critical thinking skills, as students must make decisions based on observations, experiences, and situational analysis (Coban et al., 2022). These dynamic virtual environments also facilitate discussion and collaboration, where students can share ideas and arguments in real-time, which in turn strengthens their evaluation and critical reflection skills.

Although there is much positive potential in using VR to enhance critical thinking skills, empirical research on its impact on students remains limited (Woon et al., 2021). Most existing studies tend to focus on the technological aspects and general student engagement, without specifically measuring how VR can improve critical thinking skills. On the other hand, the few studies that address this topic show mixed and inconsistent results, with some reporting significant improvements in critical thinking abilities, while others find no meaningful changes (Guntur & Setyaningrum, 2021). This highlights a research gap in the literature regarding the effectiveness of VR as a tool for developing critical thinking skills among students.

The novelty of this research lies in the specific testing of VR technology's impact on the development of critical thinking skills in students, by integrating a multidisciplinary approach that includes education, technology, and psychology. This study also aims to fill the gap in the existing literature by providing empirical evidence on the effectiveness of VR as a learning tool in the context of critical thinking. Thus, this research contributes to the development of more innovative, technology-based learning strategies focused on improving the essential skills students need in the digital era.

Methodology and Procedures

This study utilizes a literature review approach aimed at analyzing and evaluating previous research related to the impact of Virtual Reality (VR) technology on the development of critical thinking skills among university students. A literature review is chosen as it allows the researcher to gather and examine existing research findings, identify patterns, findings, and research gaps, and formulate implications for the field under study (Sugiyono, 2018). The following are detailed stages of the literature review process undertaken in this research:

1. **Identifying the Research Focus** The first stage of this research is to establish a clear focus and scope. At this stage, the researcher determines that the primary focus of the study is the relationship between Virtual Reality (VR) technology and the development of critical thinking skills among students. The researcher also sets the study's boundaries, which include only those studies that utilize VR as a learning tool and measure critical thinking skills in students.
2. **Literature Search** After defining the focus, the researcher conducts a systematic literature search from various relevant academic sources, such as scholarly journals, books, conference proceedings, and dissertations. The search is performed through leading academic databases such as Google Scholar, ScienceDirect, JSTOR, and Scopus, using specific keywords, including: "Virtual Reality in education," "Critical Thinking skills development," "University students," and "Impact of VR on learning." At this stage, an initial selection is made based on the titles and abstracts of articles to identify their relevance to the research topic.
3. **Selection and Filtering of Literature** The next step is to filter the identified literature based on established inclusion and exclusion criteria. Inclusion criteria include studies published in the last ten years, focusing on the use of VR in education, and specifically discussing critical thinking skills. Articles that do not meet these criteria, such as studies on the use of VR outside the educational context or research that does not measure

critical thinking skills, will be excluded from the analysis. Relevant literature is then classified and analyzed further.

4. **Critical Analysis of Literature** At this stage, the researcher conducts a critical analysis of the selected literature. Each article is reviewed in depth to understand the methods used, findings, and contributions to the development of critical thinking skills. The researcher evaluates whether the methods employed in the studies are valid and widely applicable, as well as identifies gaps in the existing literature. The researcher also compares results across studies to find consistent patterns or significant differences related to the impact of VR on students' critical thinking skills.
5. **Synthesis of Findings** After conducting a critical analysis, the researcher synthesizes the findings from the various studies analyzed. This synthesis not only focuses on the individual results of each study but also explores how these findings relate to each other and contribute to a broader understanding of the use of VR in developing critical thinking skills. At this stage, areas that have not been adequately addressed in the literature, as well as challenges and opportunities for further research, are identified.
6. **Writing and Compiling the Report** The final stage of this literature review is writing the research report, which presents the results of the analysis in a structured and systematic manner. The report includes summaries of the analyzed studies, main findings, and gaps identified in the literature. It will also encompass recommendations for future research and potential practical implications of the research findings. In the concluding section, a summary is provided, highlighting the contribution of VR to the development of critical thinking skills in students and how this research addresses gaps in the existing literature.

By following these stages, this literature review research is expected to make a significant contribution to understanding the impact of Virtual Reality technology on the development of critical thinking skills among university students, as well as pave the way for further research in this field. The conceptual framework of this research is presented as follows:

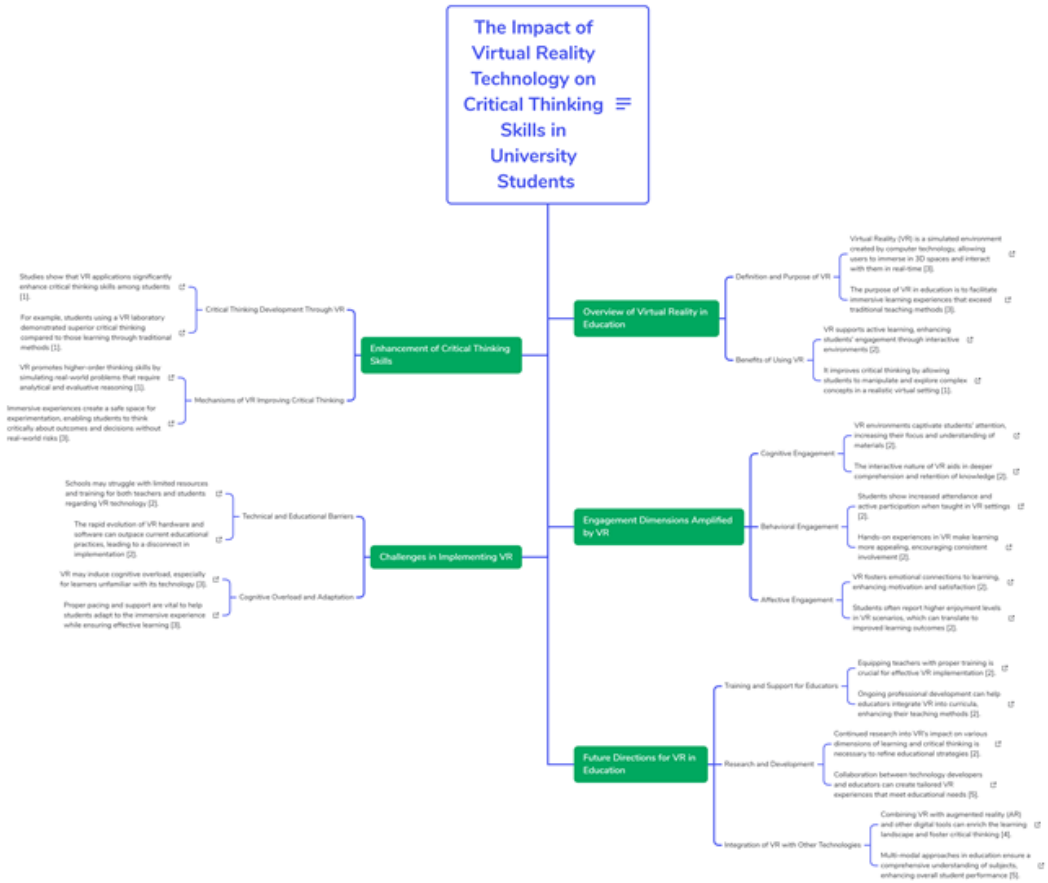

Figure 1. Research Framework

RESULTS

The results of this research, which employed a literature review method, provide an in-depth overview of the impact of Virtual Reality (VR) technology on the development of critical thinking skills among students. Based on the analysis of various studies conducted in different educational contexts, several key findings can be identified as follows:

1. **Virtual Reality Enhances Student Engagement in Learning** The results from various studies indicate that the use of VR technology in education significantly increases student engagement. VR creates a more immersive learning experience, allowing students to interact directly with simulations and virtual environments (Faridi et al., 2021). This stimulates curiosity and active participation, which are essential elements in developing critical thinking skills. Students who are actively engaged in the learning process are more motivated to solve problems, analyze situations, and make decisions based on deep thought (Syawaludin & Rintayati, 2019).
2. **Immersive VR Environments Encourage Problem-Solving and Evaluation** Some studies have shown that the virtual environments offered by VR allow students to engage in more complex and dynamic problem-solving (Kang et al., 2020). For example, simulations requiring students to resolve medical, engineering, or crisis situations can compel them to evaluate options, analyze data, and consider various perspectives before making decisions. This process directly enhances critical thinking abilities, as students must use analytical and evaluative skills to arrive at effective solutions (Astuti et al., 2020).
3. **The Use of VR Presents Challenges in Evaluating Critical Thinking Effectiveness** Although VR has great potential for enhancing critical thinking skills, some studies indicate challenges in measuring the specific impact of VR on the development of these skills (Papanastasiou et al., 2019). Most existing research only examines increases in engagement or learning satisfaction without directly measuring the enhancement of critical thinking skills. Studies measuring these skills often utilize qualitative methods, such as observation or interviews, but there has yet to be a standard assessment tool to quantitatively measure the impact of VR on critical thinking (Asad et al., 2021). Therefore, while many reports highlight the positive effects of VR, these findings are often anecdotal and require further research with more robust methodologies.
4. **The Role of Collaboration in Virtual Environments Enhances Critical Discussion** Some literature identifies that the use of VR, which allows collaboration among students in virtual environments, provides significant benefits for developing critical thinking skills (Lamb et al., 2019). Discussions that occur within VR simulations, where students must debate, discuss, and respond to their peers' arguments, create a conducive atmosphere for critical thinking (Akgün & Atıcı, 2022). They must consider various perspectives, evaluate the validity of arguments, and provide constructive feedback, thereby enhancing their skills in critical analysis and evaluation.
5. **The Use of VR Is More Effective in Contextual and Practical Learning** Several studies have found that VR is most effective in developing critical thinking skills when applied to fields requiring contextual and practical learning (S.-C. Chang et al., 2020). For instance, in medical students, VR is used to simulate complex medical procedures, providing them with opportunities to think critically in scenarios that resemble reality without actual risks. Other studies in engineering and architecture also demonstrate that using VR to model building structures or design environments enhances students' critical thinking regarding technical and aesthetic solutions (Young et al., 2020).

Thus, this research affirms that VR technology has significant potential in developing students' critical thinking skills; however, there are still methodological challenges in comprehensively evaluating its impact. This study addresses the gaps in previous research by offering new insights and directions for future studies that focus more systematically on measuring critical thinking skills based on evidence.

DISCUSSION

Virtual Reality (VR) technology is increasingly gaining attention as an innovative learning tool in higher education environments. The use of VR allows students to experience immersive learning, where they can

interact with simulated environments that resemble the real world without having to leave the classroom (Elfeky & Elbyaly, 2021). This technology opens new opportunities to facilitate a deeper learning process, particularly in developing critical thinking skills (Wu et al., 2021). Critical thinking is one of the essential abilities that students must master to face complex challenges in both professional and daily life.

VR offers a learning environment focused on problem-solving, exploration of dynamic situations, and in-depth decision-making. The virtual simulations provided by VR enable students to experience real-world scenarios directly, whether in medical, engineering, or artistic contexts (Rushton et al., 2020). This environment not only creates higher engagement but also encourages students to think critically about the actions and decisions made during the simulations. Through these simulations, students are confronted with real challenges that require analysis, evaluation, and reflection, allowing them to develop critical thinking skills more effectively than traditional passive learning methods (Hwang et al., 2022).

In the context of higher education, critical thinking skills play a vital role in preparing students to enter an increasingly complex workforce (Akdere et al., 2021). Critical thinking involves not only the ability to analyze problems but also the ability to identify appropriate solutions, make logically based decisions, and consider various perspectives. Previous research has shown that traditional learning methods, such as lectures or classroom discussions, often fall short in developing critical thinking skills. This is where VR technology becomes an innovative solution (Calvert & Abadia, 2020). The use of VR allows students to explore complex situations in a safe and controlled environment while still developing the analytical and evaluative skills that are at the core of critical thinking.

Furthermore, VR also enables collaborative learning experiences that enhance critical thinking skills. In virtual environments, students are often required to work together in groups to solve specific problems (Chien et al., 2020). This collaboration fosters interaction among students in the form of discussions, debates, and critical evaluations of the arguments and solutions proposed by their peers. This process not only improves social skills and teamwork but also deepens students' critical thinking abilities as they are confronted with diverse perspectives and must consider various arguments (Araiza-Alba et al., 2021).

However, despite the significant potential of VR in developing critical thinking skills, there are several challenges to be addressed. One of the main challenges is the lack of standardized assessment tools to quantitatively measure the impact of VR on critical thinking skills (Soto et al., 2020). Many studies involving the use of VR in learning still rely on qualitative methods such as observations or interviews, which are subjective and do not provide an accurate picture of the direct impact on critical thinking skills. Additionally, there are still limitations in long-term studies to see how students' critical thinking skills develop over time after being exposed to VR technology (Abdullah et al., 2019). The absence of longitudinal data limits our understanding of the long-term effectiveness of VR in education.

Another challenge is the technical and infrastructural constraints that educational institutions may face in implementing VR (González-Zamar & Abad-Segura, 2020). Although VR offers great potential, its implementation requires investment in advanced hardware and software, as well as training for educators and students in using the technology. Not all educational institutions have sufficient resources to adopt this technology, leading to disparities in access to innovative learning technologies like VR (Khasawneh, 2023).

On the other hand, the development of VR technology also raises ethical and pedagogical questions, particularly regarding the interaction between the virtual world and the real world (Faridi et al., 2021). Students who are overly exposed to virtual environments may have difficulty distinguishing between reality and simulation, which can affect their learning process. Therefore, it is important for educational institutions to design the use of VR with an appropriate pedagogical approach, where this technology is not only used as a learning tool but is also strategically integrated into the curriculum to enhance overall learning outcomes (Syawaludin & Rintayati, 2019).

In conclusion, despite the challenges in implementing VR technology, this research indicates that VR has great potential to be an effective learning tool in developing students' critical thinking skills. The immersive, interactive, and collaborative virtual environments allow students to explore real-world scenarios directly and make decisions based on deep analysis . The use of VR in learning offers an attractive alternative to traditional

learning methods, especially in the context of critical thinking skills that are becoming increasingly important in an era of globalization and digitization. Future research should focus on developing more comprehensive and long-term assessment tools to evaluate the impact of VR on critical thinking skills, as well as investigating how this technology can be more widely adopted across various educational institutions.

CONCLUSION

This research concludes that Virtual Reality (VR) technology has significant potential in enhancing students' critical thinking skills. Through interactive simulations and immersive environments, VR can promote active engagement, in-depth problem-solving, and collaboration among students. However, despite the proven benefits of VR, there remains a need for further research on its impacts measured quantitatively and in the long term.

RECOMMENDATIONS

Future research should focus on developing more comprehensive and standardized evaluation tools to quantitatively measure the impact of VR on critical thinking skills. Additionally, educational institutions are advised to consider the broader adoption of VR, taking into account the necessary infrastructure support and adequate training for educators and students.

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