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Metaverse Virtual Reality-Based Logistics Virtual Laboratory for Superior Indonesian Logistics

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ABSTRACTS

This study proposes the development of a Metaverse Virtual Reality-based Virtual Laboratory Logistics (ViraLL) as an innovative solution to address the gap between the competencies of graduates from educational institutions and the needs of the logistics industry in Indonesia. The background of this study is the decline in Indonesia's Logistics Performance Index (LPI) and the need to improve the quality of human resources in the field of logistics. The method used is the development of an interactive learning system using virtual reality metaverse technology that simulates real conditions in the logistics industry. ViraLL is designed with three main features: Levelling, Logisticity, and Social Interaction. The expected results are an increase in the understanding and practical skills of logistics students and an reduction in the gap between the world of education and industry. The implementation of ViraLL is projected to support the improvement of the competence of Indonesia's logistics human resources, which will ultimately drive national economic growth. This research also explores the potential for the realization of ideas, public response, copyright acquisition, PKM-KC development, and its impact on education and the involvement of authorities.

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1. INTRODUCTION

The Indonesian economy still faces challenges due to global uncertainty. Based on data from the Central Statistics Agency (BPS), Indonesia's Gross Domestic Product (GDP) growth in 2023 was recorded at 5.05%, down from 5.31% in the previous year. However, the government projects that economic growth will increase to 5.2% in 2024 and be in the range of 5.3%–5.6% in 2025. This projection reflects the government's optimism in promoting sustainable national economic growth.

The logistics sector is one of the strategic sectors in supporting this economic growth. The Coordinating Minister for Economic Affairs of the Republic of Indonesia emphasized that an efficient logistics system is the key to realizing quality economic growth. A good logistics system can encourage equitable infrastructure development and economic activity in various regions of Indonesia, while supporting the achievement of the Indonesia Emas 2045 vision.

However, Indonesia's logistics performance in recent years has shown a downward trend. Based on 2023 World Bank data, Indonesia's Logistics Performance Index (LPI) score declined from 3.15 with a ranking of 46th in 2018 to 3.00 with a ranking of 61st in 2023. One of the main causes of this decline is the weakening of logistics competence and service quality, as reflected in the decline in the logistics competence and quality indicator score from 3.1 to 2.9 during the same period.

This decline in logistics quality indicates the need to improve the competence of logistics human resources (HR). The gap between educational institutions and the needs of the logistics industry remains an obstacle in preparing a ready-to-work workforce. Therefore, learning innovations are needed that can provide realistic practical experience, one of which is through the use of virtual reality-based metaverse technology to simulate logistics industry conditions. This innovation is expected to improve the quality of Indonesia's logistics human resources and promote the sustainable efficiency of the logistics sector.

2. METHODS

2.1 Type and Approach of Research

This research uses a descriptive qualitative method with a literature review approach. This method aims to analyze the phenomenon of declining logistics performance in Indonesia, the need to improve the competence of logistics human resources, and the relevance of developing virtual reality metaverse-based learning media in the context of vocational education. This approach allows researchers to obtain a comprehensive picture of the trends, challenges, and opportunities for implementing virtual reality technology in logistics education.

2.2 Literature Collection and Selection Techniques

Literature collection was carried out by collecting, reviewing, and synthesizing various scientific sources, such as national and international journals, official reports, government regulations, books, and publications related to virtual reality technology and vocational education. To ensure a systematic search process, this study established the following literature collection procedures:

(1) identification of keywords such as "logistics performance index," "metaverse education," "virtual reality learning," "vocational education," and "logistics human resources";
(2) literature search through databases such as Google Scholar, Scopus, ScienceDirect, ministry portals, and official reports from international organizations;

(3) selection of literature based on titles and abstracts to ensure relevance to the topic;
(4) in-depth reading to extract relevant concepts, data, and findings;
(5) grouping of literature into main analysis themes.

Literature selection criteria were established to maintain the quality and credibility of sources, namely:

(1) literature must be relevant to the topics of logistics, vocational education, VR/metaverse technology, or competency development;
(2) it must come from credible sources such as indexed journals, scientific proceedings, academic books, official reports (World Bank, BPS, Coordinating Ministry for Economic Affairs), and government regulations;
(3) have a publication range of 2018–2024 to ensure the information is up to date;
(4) provide empirical data or theoretical concepts that support the analysis.

2.3 Data Analysis Techniques

The analysis was conducted using a thematic analysis approach, grouping data from various literature into several main themes, such as the condition of national logistics performance, human resource competency challenges, and the potential use of VR technology in vocational education. The results of the grouping were synthesized narratively to formulate the concept of Virtual Laboratory Logistics (ViraLL) development.

3. RESULTS AND DISCUSSION

3.1 Virtual Reality in the Context of Logistics Learning

Virtual Reality (VR) is a technology that allows users to interact directly with a three-dimensional virtual environment simulated by a computer, creating an immersive learning experience that resembles real-world conditions. Through supporting devices such as head-mounted displays and controllers, VR can increase users' situational awareness, expand visual perception, and facilitate a deeper understanding of complex objects and processes compared to conventional learning media (Radianti et al., 2020; Jensen & Konradsen, 2018).

In the context of education, VR not only functions as a visualization medium, but also as an interactive learning environment that allows students to explore, make decisions, and reflect directly in virtual scenarios. Various studies show that VR-based learning can increase student engagement, motivation, and conceptual understanding because it provides experiential and contextual learning experiences (Makransky et al., 2019; Parong & Mayer, 2018).

The application of VR in logistics learning is becoming increasingly relevant given the complex and dynamic nature of logistics processes, which involve many operational stages. Through VR-based simulations, logistics activities such as inventory management, warehousing, transportation, and distribution flows can be visualized realistically without the limitations of physical facilities. This approach allows students to understand the interrelationships between logistics processes holistically and develop the analytical and decision-making skills needed in the modern logistics industry (Radianti et al., 2020; Merchant et al., 2014).

3.2 The Use of VR as a Learning Medium

The use of Virtual Reality (VR) as a learning medium in vocational education has been proven to provide a more engaging, effective learning experience that closely resembles real-world working conditions. Through an immersive virtual environment, students can learn industrial work processes visually and interactively, thereby improving conceptual

understanding and practical skills compared to conventional text- or video-based learning (Allcoat & Mühlenen, 2018; Wu et al., 2020).

In addition to improving understanding, VR also provides a safe and controlled learning environment, where students can practice and simulate without safety risks or material losses. These characteristics make VR highly relevant for vocational education that requires practical mastery, especially in fields with high levels of complexity and operational risk. Various studies show that VR-based learning has a positive impact on improving students' knowledge, cognitive skills, and practical abilities with significant effectiveness (Kyaw et al., 2019; Makransky et al., 2019).

VR-based learning also shows a more positive trend in the development of non-technical competencies compared to regular learning. 's virtual environment enables active interaction, collaboration, and communication among learners, thereby encouraging the development of teamwork, problem-solving, and decision-making skills. These aspects are important competencies that are highly sought after in the modern industrial world (Villena-Taranilla et al., 2022; Marion et al., 2023).

In the context of logistics learning, VR serves as a medium capable of visualizing complex and dynamic logistics processes, such as inventory management, warehousing, transportation, and distribution. Through VR-based simulations, students can directly experience logistics workflows and understand the interrelationships between processes without the limitations of physical facilities. This approach helps students gain a more realistic picture of the competency requirements of the logistics industry and improves the work readiness of vocational education graduates (Radianti et al., 2020; Pickering et al., 2024).

3.3 Introduction to the Virtual Laboratory Logistics (ViraLL) Innovation

Overcoming the gap between the competencies produced by educational institutions and the needs of the industrial world requires revolutionary innovation. Virtual Laboratory Logistics (ViraLL) enables educational institutions to keep up with the latest trends in equipment used in the logistics industry without incurring excessive purchase and maintenance costs.

ViraLL is an interactive integrated learning innovation that uses VR to depict real-world situations in the industry. This innovation illustrates all logistics activities, provides various multimodal transportation options, and highlights various problems that may be encountered during the process. ViraLL enables real-time interaction with users without location restrictions. This tool was created to provide alternative options in the event of a pandemic. Users can visualize real logistics activities, such as receiving goods, collecting stock, and delivering goods, using real procedures.

ViraLL utilizes several technologies to support a more realistic experience for its users. These technologies include Virtual Reality Glasses and hand Controllers. Virtual reality glasses provide a direct experience of seeing and interacting in logistics activities that are realistic replicas of the industrial world. In addition, hand controllers allow users to operate devices and carry out various logistics activities efficiently, as well as navigate more realistically in the virtual reality world. The combination of these two technologies ensures that users can work effectively and responsively in executing their logistics operations.

ViraLL also features functions like leveling, logistivity, and social interaction, providing users with an immersive experience in understanding and managing various aspects of

logistics, thereby enhancing their adaptability and decision-making capabilities in diverse situations.

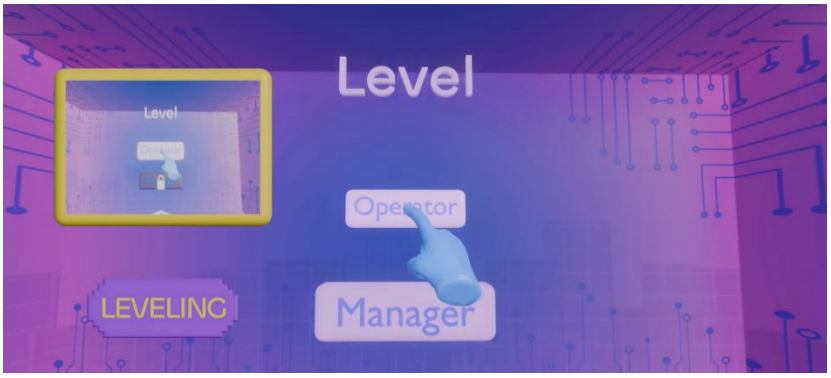

Figure 1. Leveling Feature

The leveling feature allows users to adjust the difficulty level as needed, such as operational level for vocational school students and managerial level for university students. Additionally, the logistivity feature depicts logistics activities in line with real-world industrial conditions.

Figure 2. Logistivity Feature

The logistivity feature includes various logistics stages and provides students with the opportunity to practice operating logistics equipment.

Figure 3. Social Interaction Feature

The social interaction feature allows students to discuss and interact directly in the process, reflecting the importance of communication and teamwork in effective logistics management in the industrial world. Therefore, ViraLL is expected to improve students'

understanding of real-world work situations and address the three differences between the skills produced by schools and those required by industry.

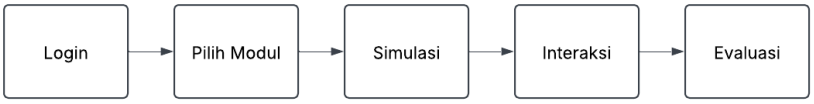

Figure 4. User Flow Diagram

The Virtual Laboratory Logistics (ViraLL) user flow diagram illustrates the stages of user interaction in utilizing virtual reality-based learning media. The process begins with users, both vocational school students and university students, accessing the system and selecting logistics learning modules according to their competency needs. Next, users enter a virtual simulation environment that represents real-world logistics activities, such as inventory management, goods movement, and distribution flows.

During the simulation stage, users can interact with various objects and logistics scenarios through interactive features, including leveling, logistivity, and social interactions that support collaboration. The learning process then ends with an evaluation stage, where users receive feedback on their performance and understanding of logistics concepts. This flow is designed to create a learning experience that is systematic, intuitive, and close to the operational conditions of the logistics industry.

3.3.1 Comparison of ViraLL with Conventional and Technology-Based Logistics Learning Media

To emphasize the position of Virtual Laboratory Logistics (ViraLL) as an innovation in virtual reality-based logistics learning, a comparative analysis with previously used logistics learning media is required. This comparison aims to show the characteristics, advantages, and limitations of each learning medium in supporting the mastery of logistics competencies in vocational education. Through this comparative analysis, it is hoped that the contribution of ViraLL in addressing the gap between learning in educational institutions and competency requirements in the logistics industry will become clear.

The logistics learning media compared in this study include conventional logistics practicums based on physical laboratories, e-learning or learning management system (LMS)-based logistics learning, and non-virtual reality computer-based logistics simulations. Conventional practicums generally rely on physical facilities and real equipment, while e-learning emphasizes online delivery of material with limited practical experience. Non-virtual reality logistics simulations provide visualization of logistics processes through computer devices, but do not yet provide an immersive learning experience. As the main comparison, Virtual Laboratory Logistics (ViraLL) was developed using virtual reality and metaverse technology to provide interactive, immersive logistics activity simulations that closely resemble real industry conditions.

Table 1. Comparison of ViraLL with Conventional and Technology-Based Logistics Learning Media

Comparison Aspects	*Conventional Logistics Practicum*	*Logistics E-learning (LMS)*	*Non-VR Logistics*	*ViraLL (VR & Metaverse)*

			Simulation (Desktop)	
Level of learning immersion	Low	Low	Moderate	High (immersive VR)
Visualization of logistics processes	Limited to physical tools	2D visuals (video/graphics)	2D/3D digital visuals	Interactive 3D visuals that are close to reality
User interaction	Direct, limited space	Limited (forum/assignments)	Mouse/keyboard-based interaction	Natural interaction through VR & controller
Simulation of real industrial conditions	Limited facilities	Very limited	Fairly representative	Close to real industrial conditions
Flexibility of time & place	Low	High	High	High
Safety risk	Present (equipment & physical environment)	None	None	None
Long-term implementation costs	High (equipment & maintenance)	Low–medium	Moderate	Relatively efficient in the long term
Adaptation of competency level	Not adaptive	Not adaptive	Limited	Adaptive (vocational high school–university students)
Soft skills development	Limited	Limited	Moderate	High (collaboration & communication)
Suitability for vocational education	Sufficiently suitable	Sufficiently suitable	Suitable	Highly suitable

Based on Table 1, it can be seen that each learning medium has its own characteristics and contributions to logistics learning. Conventional logistics practicums play an important role in mastering operational basics, but have limitations in terms of flexibility, cost, and safety risks. E-learning logistics learning excels in terms of accessibility and flexibility, but is not yet able to provide an in-depth practical experience. Desktop-based non-virtual reality logistics simulations offer better visualization of logistics processes than e-learning, but are still limited in terms of user immersion and interaction.

As the main comparison, Virtual Laboratory Logistics (ViraLL) shows superiority in almost all aspects of comparison, particularly in terms of learning immersion, simulation of real industrial conditions, adaptation of competency levels, and development of soft skills through social interaction- . These characteristics make ViraLL more relevant to the context of logistics vocational education, which demands practical experience, collaboration, and work readiness. Thus, ViraLL has the potential to be an effective logistics learning medium to bridge the gap between learning in educational institutions and competency requirements in the logistics industry.

3.4 Parties Involved in ViraLL

Collaboration between various stakeholders is crucial in the implementation of ViraLL. First, learning media experts help validate the functionality of the learning media that will be used by vocational schools, ensuring that the technology applied can be used effectively and efficiently. Second, vocational education institutions, particularly vocational schools, play a role in allocating resources to provide the necessary hardware and software. In addition, they integrate the use of technology and the learning curriculum so that learning materials can be adapted to current needs. Third, collaboration with the logistics industry is very important, as it opens up opportunities to integrate real-world learning experiences with simulations. The industry can provide realistic virtual practicum experiences, helping students gain practical skills that are relevant to market needs. Fourth, education agencies are involved in developing policies, standards, and guidelines related to the use of ViraLL in vocational schools, as well as providing training to educators on the integration and use of virtual reality metaverse-based learning innovations. Sixth, investors play a key role in supporting the development of the necessary technology and platforms. Investor involvement includes funding, technology development, market expansion, and provision of access, all of which support the creation of innovative and effective learning experiences. Through collaboration with various parties, it is hoped that the implementation of ViraLL in vocational schools can run successfully, supporting the improvement of vocational education quality and alignment with industry needs.

3.5 Benefits of Implementing ViraLL in Vocational Education

ViraLL, based on virtual reality metaverse, has the potential to be realized in Indonesia as an innovative solution for logistics education. This idea overcomes the limitations of access to expensive industrial equipment and the difficulties of industrial visits, which are in line with the global trend of adopting educational technology and the government's efforts to improve the quality of logistics human resources to increase Indonesia's LPI.

The ViraLL innovation has a positive impact on the education sector, industry, society, and the economy. First, the ViraLL innovation can assist teachers in the learning process, thereby creating a learning experience that is in line with the curriculum and learning objectives. Second, the benefits that students will gain if the ViraLL idea is realized are that they will

obtain an in-depth and realistic learning experience in the field of logistics. In addition, students can have a better understanding of logistics learning concepts that are difficult to understand with theory alone. Third, the potential benefits for industry are that the industrial world will be helped because vocational school graduates will be better prepared for work and qualified for industry needs. Fourth, the benefits to the economy. The ViraLL innovation can reduce costs incurred by industries, especially in the logistics industry, because in addition to vocational school graduates being ready to work in the industrial world, the ViraLL innovation can cooperate and coordinate well. A good logistics system can influence the equitable distribution of infrastructure and economic development throughout Indonesia, which can be improved by this ViraLL innovation.

3.6 Conceptual Implementation of Virtual Laboratory Logistics (ViraLL)

The implementation of the Virtual Laboratory Logistics (ViraLL) in this study focuses on the conceptual design of developing virtual reality-based logistics learning media. The implementation is designed to support vocational learning by presenting logistics process simulations that resemble real industrial conditions, enabling students to gain virtual practical experience before entering the actual work environment.

The stages of ViraLL implementation include analyzing logistics learning needs, developing logistics process simulation scenarios, developing a virtual environment that represents logistics activities such as inventory management, stock movement, and distribution flows, and integrating interactive features. These features include leveling for gradual learning, logistivity to increase user engagement, and social interaction to simulate collaboration in logistics systems. All stages of implementation are represented through visual media in the form of conceptual prototypes.

This conceptual implementation is designed as a flexible and safe learning support medium for logistics practical training, without dependence on physical industrial facilities. With this approach, ViraLL has the potential to help bridge the gap between learning in vocational education institutions and competency requirements in the logistics industry, particularly in improving students' conceptual understanding and decision-making skills.

As a form of initial validation of the ViraLL concept, the conceptual output of this research received positive responses from the public. Visual media representing the ViraLL concept received a fairly high level of engagement, as reflected in the number of views, interactions, and constructive comments. These responses indicate the potential for initial acceptance of the Virtual Laboratory Logistics concept as a virtual reality-based logistics learning medium.

4. CONCLUSION

Virtual Laboratory Logistics (ViraLL) is an innovative learning approach that utilizes virtual reality (VR) technology to simulate real-world logistics activities in an interactive and immersive manner. Through this virtual environment, users can visualize various logistics processes, such as inventory management, stock movement, and transportation, without the limitations of time and physical facilities. Support for VR devices, such as virtual reality glasses and hand controllers, as well as leveling, logistivity, and social interaction features, enable improved conceptual understanding, adaptability, and decision-making. Thus, ViraLL has the potential to be an effective learning medium to bridge the competency gap between educational institutions and the needs of the logistics industry.

However, this study still has several limitations. The development of ViraLL in this study is still conceptual and has not been directly implemented in the formal learning process. In addition, the evaluation of learning effectiveness has not been carried out quantitatively through empirical testing. The aspects of infrastructure readiness and the level of user acceptance of virtual reality technology have also not been studied in depth. Therefore, further research is expected to carry out direct implementation, measurable evaluation, and testing of the sustainability of ViraLL as a logistics learning medium.

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