Transforming heavy equipment engineering learning using virtual reality: A literature review and case study

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ABSTRACT

The transformation of education in Indonesia is influenced by the development of digital technology. Over time, the world of education in Indonesia is able to transform to keep up with developments in the digital era. One form of transformation is learning through virtual reality media. This research aims to explore the impact of virtual reality transformation on learning heavy equipment engineering. The research methods used in this research are case studies and literature. A quantitative approach through quasi-experimental research with a post-test only control group design, was also used to gain a deeper understanding of the impact of virtual reality on learning outcomes. The data obtained was analysed using descriptive methods, qualitative data was analysed using qualitative descriptive, and quantitative data was analysed using quantitative descriptive. The results of the analysis show that learning transformation is needed so that it can be carried out properly in accordance with various environmental conditions. The use of virtual reality in learning heavy equipment engineering encourages digital learning transformation to improve the quality of learning through simulation of practical learning. The use of virtual reality in learning heavy equipment engineering can improve student understanding, although virtual reality transformation cannot fully replace the role of conventional learning because there are some competencies that must be taught directly. Although this research is exploratory, the empirical insights gained can make a valuable contribution as a reference for the development of virtual reality-based learning.

INTRODUCTION

The world of education in Indonesia is forced to transform along with the development of the world situation. For example, the world of education was forced to transform due to the COVID-19 Pandemic when all schools were conducted remotely, both online and offline (Carrillo & Flores, 2020; Donitsa-Schmidt & Ramot, 2020). At that time, the application of technology in learning was increasing in an effort to ensure that learning was still carried out as optimally as possible. This transformation of education in Indonesia has experienced obstacles, including infrastructure, learning methods, and socio-culture (Rigianti, 2020). Nevertheless, after the pandemic situation, the implementation of technology in learning continues to be carried out and even continues to develop along with the development of the digitalization era.

The digitalization era requires all people to submit to the progress of the times in all fields. It is undeniable that as a result of this, the world of education is one aspect that is also affected. The world of education is required to adapt and integrate the development of science and technology into subject matter holistically (Ngongo et al., 2019). Over time, the education world in Indonesia has transformed to keep up with developments in the digital era.

One form of transformation is learning through Virtual Reality (VR) as a learning medium. Virtual reality is a combination of hardware combined with a computer or smartphone to produce simulation results about the environment or area in three dimensions so that users can interact in the real environment or the sense of an environment simulated by a computer (Abdillah et al., 2018; Sarosa et al., 2019). Meanwhile, learning media is a tool that helps the teaching and learning process so that learning becomes better (Wing, 2010). Digital-based learning media can assist teachers in delivering learning materials in various ways. Digital learning media can help concretize concepts and can motivate students to learn actively (Karo-Karo & Rohani, 2018). Based on this potential, the impact of virtual reality transformation as a learning medium needs to be explored.

The impact of virtual reality as a learning medium has been widely discussed. Virtual reality facilitates an interactive learning environment and provides learning experiences that support students' abstract thinking and communication (Fernandez, 2017). The implementation of virtual reality as a learning medium can build students' confidence (Frisby et al., 2020) and provide opportunities for students to improve their speaking skills in a virtual environment (Kryston et al., 2021). Furthermore, several studies show the effectiveness of virtual reality as a learning medium in improving student learning outcomes, including research by Bibic et al. (2019), Buttussi and Chittaro (2018), Leder et al. (2018), Shi et al. (2019), Valdesolo et al. (2017), and Jang et al. (2017). However, the impact of virtual reality that has been discussed is generally related to its implementation in general learning, while the discussion regarding the impact of virtual reality transformation on vocational learning is still limited.

Based on the background of the problem and previous studies, this research article is conducted to discuss the use of virtual reality (VR) in the context of heavy equipment engineering learning. The research includes a literature review on the application of VR in education as well as a case study evaluating the effectiveness of using VR in heavy equipment engineering learning. Through the literature review, this article presents a comprehensive understanding of the concept and application of VR in learning. The included case studies provide insights into the practical experiences and outcomes gained from the implementation of VR in heavy equipment engineering learning. This research aims to explore the potential of VR as an innovative and effective learning tool for strengthening students' skills in operating heavy equipment.

This research explores virtual reality transformation's impact on vocational learning. This research focuses on the impact of using virtual reality as a vocational learning medium that has been carried out by Vocational High Schools (VHS) in Indonesia in learning heavy equipment engineering. Heavy equipment engineering is a field in the automotive sector that focuses on semi/full trailer trucks, dozers, excavators, mobile cranes, wheel loaders, etc. As such, the article can contribute to the academic literature by providing a deeper understanding of the potential use of VR in learning heavy equipment engineering, as well as providing practical insights for educational practitioners and curriculum developers.

METHOD

The research methods used in this research are literature studies and case studies. The data collection technique in the literature study was carried out by reviewing several scientific articles obtained through Google Scholar, the articles used were articles published from 2014-2024 with the keywords used were heavy equipment engineering, learning, and virtual reality. Data collection techniques in case studies are carried out through observation and interviews. A quantitative approach through a quasi-experiment with a posttest-only control group design was also used to gain a deeper understanding of the impact of virtual reality on learning outcomes. The sampling technique used was purposive sampling. Observations were made on heavy equipment engineering learning at SMKN 1 Negeri Semarang. Interview respondents were 10 teachers at SMK Negeri 1 Semarang who used virtual reality as a learning medium in heavy equipment engineering lessons. The research instruments used for observation are observation sheets, and interview guidelines are used for interviews. Before use, the instruments were validated using the expert judgment method. Data obtained from observations and interviews were analyzed using the descriptive qualitative method.

Meanwhile, this study used a quasi-experiment method with a posttest-only control group design involving 36 students of class XII Heavy Equipment Engineering (TAB) 1 and 36 students of class XII TAB 2 of SMK Negeri 1 Semarang. Class XII TAB 1 is the experimental class, and class XII TAB 2 is the control class. The experimental class is the group that is given treatment, namely by learning using virtual reality media. The control class is a group of students whose learning uses student worksheets. The data collection technique used was the test method, which used a questionnaire. This research was conducted in 4 (four) meetings, consisting of 3 (three) learning processes and one meeting for posttest. The posttest questionnaire was validated using the expert judgment method. Based on the data that has been obtained, quantitative descriptive analysis is carried out to determine the high and low quality of learning outcomes.

RESULTS AND DISCUSSION

Results

Review of Virtual Reality Transformation

Virtual reality is a technology that allows users to enter the virtual world and interact in it because virtual reality is a computer-based technology that combines special input and output devices so that users can interact deeply with virtual environments as if they were in the real world (Chandel & Chauhan, 2014). Virtual reality is a combination of hardware combined with a computer or smartphone to produce simulation results about the environment or area in three dimensions, so that users can interact in a real environment or in terms of a computer-simulated environment (Abdillah et al., 2018; Sarosa et al., 2019).

Bondarenko (2021) explains that virtualistics, as a relatively new area of cognition, is a new paradigm approach to understanding objects and processes in the context of a large-scale deployment of virtual reality. In other words, virtual reality presents new innovations in related technologies through the use of virtual. It is understood that virtual reality is composed of combined hardware that produces a virtual area. In line with this, Sinambela et al. (2018) explain that the resulting area is a replica or imitation of the actual area with three-dimensional settings, images, and sound.

This means that all device components that make up virtual reality can produce virtual areas that affect the user experience. Meanwhile, Darojat et al. (2022) suggest that through the development of virtual reality media, using the unity application is useful for creating the expected virtual area. Furthermore, Torous et al. (2021) explain that virtual reality enables precise and real-time data capture from responses to stimuli in a controlled virtual environment. Thus, if all devices are complete, virtual reality media will function properly and present real-world visualizations in a virtual environment through programmed data capture.

One of the advantages of virtual reality as a digital technology is that it provides convenience for its users. As stated by Mambu et al. (2019) that one of the cheapest and easiest virtual reality implementations is to use a smartphone, the advantage is that smartphones have two important sensors to support a virtual reality application, namely accelerometers and gyroscopes. Syafril (2019) further explains that this virtual video is easily accessible via YouTube on the condition that it has internet and virtual reality gadgets (S-VR). S-VR is an optical glass with two convex glasses on the VR glasses, so the VR S-VR utilizes gadgets with Gyroscope features on the device. Thus, the use of virtual reality media makes use of tools that are practical and easily accessible.

Another advantage of virtual reality media, according to Kurniawati et al. (2020), is that VR uses tools that make people feel another visual experience in the form of 3D images. In line with this, Pranata et al. (2018) explain that virtual reality provides an experience that makes users feel the sensation of the real world in cyberspace. Pakpahan et al. (2020) further argues that virtual reality media has provided a more interesting and real display environment. Thus, virtual reality provides important benefits for its users. Based on some of these studies, the presence of virtual reality media can provide an innovation for the world of education.

Virtual reality can be adapted and applied to various fields, including education. In the field of education, virtual reality is used as a medium to help students understand things that are difficult

to imagine, facilitate understanding for students who have low learning abilities, accelerate the learning process, and save operational costs in the learning process. Al-Azawi et al. (2019) say that technological advances open up new ways for educators to use virtual reality in practice and ensure learning success. That is, with technological advances, Virtual reality can be used as a medium for teachers to achieve the expected learning objectives. Furthermore, Jensen and Konradsen (2018) explain that learning with virtual reality can support the understanding of information both visually and spatially.

It can be understood that virtual reality media provides a new learning experience for students, where students will be directly involved in seeing the real virtual world through dynamic images so that students feel as if they are in the real world. Virtual reality-based computer assembly learning media can be used by students anytime and anywhere so that students can learn without being limited by space and time. The media is used repeatedly and will not damage the object because it is only a visual object.

There are several studies on transforming virtual reality technology as a learning medium. Among them is research conducted by Musril et al. (2020) in their article entitled implementation of virtual reality technology in computer assembly learning media. The results of this research concluded that the virtual reality application of computer design can be played using cardboard so that it can interact with the virtual reality environment as if it were in the real world. The application has a responsive display and can be run on smartphones with the Android operating system, and users must wear Google Cardboard or VRBox glasses. Another study is research with the title Development of 3D virtual reality application introduction to Indonesian ancient humans for class X SMA (Case study of SMA Negeri 2 Singaraja) by Wardhana et al. (2019). The application in this study has two modes, namely learning mode and playing mode, where in learning mode, users can see information about the types of ancient humans in Indonesia. While in play mode, players can play games about ancient humans for 60 seconds. This application received a positive response from users.

The next research is research with the title development of learning media for the introduction of virtual reality-based fish types (Kusuma et al., 2018). In this research, the authors used several applications, namely the C sharp programming language, Unity for making virtual reality-based applications with the Google VR SDK for Unity framework, Blender 3D for making 3D objects of fish and underwater environments along with fish movement animations, GIMP for making textures, icons and background images, and audacity for editing narration sounds. This application can be installed on Android smartphones with the Ice Cream Sandwich system and above.

The last research is a study entitled designing a virtual reality-based Balinese Fruit Shooter game as a learning media, by Mambu et al. (2019). In this research, the author introduces local Balinese fruits to the younger generation, especially kindergarten children, through games and helps the learning process in kindergarten with the subtheme of fruits. This research results in a virtual reality-based Balinese Fruit Shooter game application that can be played through a computer with an HTC VIVE device. This application obtained the results of testing the correctness of the process by 96%, testing the feasibility as an educational game for introducing local Balinese fruit with 95% results, media expert testing obtained 96.5% results, and material expert testing obtained 97.5% results.

Virtual reality is a digital-based media. Saputro and Setyawan (2020) explain that digital media can provide opportunities for a more effective teaching process. However, some things need to be considered when practicing learning using digital media. These are related to social relations and ethical issues. Therefore, when teachers want to develop digital technology, they must think about how to present interesting and effective information so that teaching can improve the learning process while maintaining students' way of thinking, behavior, social practices, and courage.

One thing that must be considered before applying virtual reality media is that teachers must first introduce virtual reality media to students. In line with this, Breedt and Labuschagne (2019) explain that before using virtual reality, there needs to be a briefing regarding how to use it, this is done as an effort to reduce students' feelings that arise due to adaptation of new media. Thus, teachers must carry out stages when they want to use virtual reality media in the learning process.

First, students are introduced to virtual reality media. This aims to get students used to using virtual reality media. Initially, according to Daniela (2020), participants can be represented in a specifically created three-dimensional environment through 'avatars' or figurative individuals. In other words, the first step in using virtual reality is for students to know that they will be taken into a 3-dimensional world. In line with this, Wiradhika et al. (2021) said that the use of virtual reality as an educational media involves users in four things, namely immersion, presence, empathy, and embodiment. Thus, students will feel these four things when learning to use VR media.

In the second stage, each student will be paired with virtual reality media, told about how to use it, and students will be given an explanation of the learning material that students will see in virtual reality media, conduct questions and answers about the material with the aim that students can at least understand before students enter virtual reality media. Students will see and listen to impressions about the material, and the teacher instructs students to focus on seeing and understanding the material. The third stage is the evaluation stage. Teachers can adjust the purpose of using virtual reality with material indicators to be achieved. For example, virtual reality media is used to make students better understand a particular subject so that teachers can easily see students' cognitive, affective, and psychomotor abilities.

Some research results show the success of applying virtual reality media to learning, namely research by Muslih (2020), which shows that this virtual reality learning application makes it easier for students because it supports e-learning so that students can learn anywhere and anytime. Similar results are also proven based on research conducted by Putra and Aisyah (2021), which shows that virtual reality media is very effective to use. Furthermore, Supriadi and Hignasari (2019) research shows that virtual reality-based learning media used in learning is declared more effective and able to improve student learning outcomes. In addition, the results of Velev and Zlateva (2017) research show that virtual reality successfully educates students in all subjects.

Thus, based on the results of the literature review show that the impact of the application of vocational learning using virtual reality has not been widely explored, in other words, the positive effect of using virtual reality in vocational learning, especially in heavy equipment engineering learning, is not yet known. In fact, technological developments are in line with the development of vocational learning, so it is necessary to develop media that support the development of vocational learning (Wulandari et al., 2019), including virtual reality transformation in heavy equipment engineering learning. Therefore, this study reveals the impact of virtual reality transformation on vocational learning, especially in heavy equipment engineering learning. Examining the phenomenon of virtual reality transformation in the context of vocational education is an important priority to improve the quality of vocational learning, especially in heavy equipment engineering learning in the digital era.

Case Study of the Impact of Virtual Reality Transformation on Heavy Equipment Engineering Learning

Based on the results of observations and interviews, digital transformation has been carried out on the media and methods of learning heavy equipment engineering at SMK Negeri 1 Semarang since the pandemic era. Some lessons with classical delivery are replaced with video conferencing through the MS Teams application. The learning media has been digitized, textbooks are scanned and made into ebooks, and related materials are delivered through MS Teams and the e-Public Library of SMK Negeri 1 Semarang. Digital transformation in learning heavy equipment engineering at SMK N 1 Semarang is carried out due to the demands of environmental conditions.

The transformation is carried out on media and learning processes that have been combined with digital media. SMK N 1 Semarang, majoring in heavy equipment engineering, still needs practical equipment, so students have difficulty in understanding and practicing practicum material. The lack of practical tools owned by the school is due to the relatively high cost of buying these tools. Many existing practical tools are damaged due to usage and limited maintenance due to high maintenance costs. SMK Negeri 1 Semarang is a school that has a partnership in which there is an industrial cooperation program, one of which focuses on curriculum synchronisation and virtual reality transformation in learning.

Virtual reality transformation in heavy equipment engineering learning is carried out in practical learning activities, where vocational students, to achieve competence, need to do training and practice. SMK Negeri 1 Semarang utilizes virtual reality transformation into a mixed model, where for initial training, students use virtual reality. After all virtual reality tasks and practices are completed, students practice directly on heavy equipment units. Practice in the unit takes less time than before applying virtual reality media because before doing practice in the unit, students already understand and know the unit through the use of virtual reality media.

However, this transformation must be partially applied. Classical learning is still needed to teach directly about the competencies that must be achieved by heavy equipment engineering students of SMK Negeri 1 Semarang. In line with this learning, the requirement to obtain a certificate of competence in the field of heavy equipment is obtained after doing direct work for at least several hours and cannot be replaced by virtual reality. Hopefully, in the future, there will be policies in the field of education that are in line with digital transformation in heavy equipment engineering vocational education.

Based on the results of quasi experiment research with posttest only control group design, the average posttest learning outcomes in the experimental group were greater than the control group after being treated. There are higher learning outcomes between students who learn using virtual reality media and students who learn using student worksheets in class XII TAB 1 SMK Negeri 1 Semarang. It can be seen that the average learning outcome of the experimental group using virtual reality media is 90.33, while the average posttest of the control group is 78.33. Based on the average learning outcomes, the learning outcomes are higher in students who use virtual reality media. The results of the analysis of student responses from the application of virtual reality media on vehicle recognition material can be seen from the average student response score of 4.58, which is included in the very positive category.

During learning using virtual reality media, the activities carried out by students are observing, listening, and simulating practicum activities virtually. Through virtual reality media, students get direct experience without having to go to the observed object. For example, when students clean the air filter, they do not have to clean the object directly. Because students can observe vehicles in the air through virtual reality media. This is also supported by the theory that virtual reality media is easy to use, provides better visual information, is fun so that students do not feel bored and helps improve student understanding, while when using student worksheets.

The activities carried out by students are learning and working on assignments given by the teacher. Where through the student worksheet media, the teacher only provides material in the form of images. In essence, memory is directly related to experiences that have been seen and what happens in the surrounding environment. Therefore, the use of virtual reality media makes students' memories stronger, so learning outcomes also increase, compared to using student worksheets that only provide instructions and steps for completing tasks without providing experience to students.

Discussion

The analysis shows that learning transformation is needed due to various environmental conditions. At SMK N 1 Semarang, learning transformation is carried out because it is affected by the pandemic situation and continues with the transformation of virtual reality in learning due to the demands of technological developments supported by industrial collaboration. Virtual reality is a media that can present a real situation for its users, so that users can feel the atmosphere like what is in the media.

The implementation of virtual reality media in learning in vocational high schools is by linking the context of the content of learning materials with virtual reality itself. The use of virtual reality in learning heavy equipment engineering encourages digital learning transformation to improve the quality of learning through simulation of practical learning. The learning material presented in virtual reality media presents a 3-dimensional visual display so that students can appropriately record the material in virtual reality media. Furthermore, Wiradhika et al. (2021) explained that the use of virtual reality as an educational media involves users in four things, namely immersion (deep experience), presence, empathy, and embodiment. The influence of visualization

presented by virtual reality media can deepen students' understanding of the concepts of the material provided.

Learning with virtual reality media is able to provide meaningful experiences for students. Virtual reality media provides a new learning experience for students, where students will be directly involved in seeing the real virtual world through dynamic images so that students feel as if they are in the real world. This is in line with the results of the case study, which states that learning with virtual reality media can improve student learning outcomes.

The use of virtual reality in learning heavy equipment engineering can improve student understanding, although virtual reality transformation cannot fully replace the role of conventional learning because some competencies must be taught directly. In addition, when applying virtual reality to learning, teachers' methods and strategies for teaching need to be considered. Teachers are required to have digital competence in order to utilize virtual reality media in learning. Teachers must be equipped with digital competencies and recognize various types of digital-based learning media. This is intended so that teachers are able to utilize virtual reality transformation as an appropriate digital-based learning media (Sulistyowati & Rachman, 2017).

This article can significantly contribute to the academic literature by presenting a comprehensive literature review on virtual reality (VR) applications in heavy equipment engineering learning. It can help broaden our understanding of the potential of VR technology in the context of engineering education. This research has important practical implications for educational institutions and teachers in designing more effective learning programs. The use of VR can be considered an innovative approach that can improve the quality of heavy equipment engineering learning by providing a more interactive and immersive experience for students. This research can support the further development of educational technology by highlighting the use of VR in heavy equipment engineering learning. It can encourage software and hardware developers to continuously improve VR's ability to provide a more realistic and effective learning environment.

The case studies included in this research may have limitations regarding sample size, population representation, or generalisability of findings. Therefore, the results from the case studies in this research may only be directly applicable to some heavy equipment engineering learning contexts. Furthermore, while this article may provide valuable insights into the use of VR in heavy equipment engineering learning, it is important to remember that each learning context has unique challenges and needs. Therefore, the results from this study should be considered carefully before being applied generally.

CONCLUSION

Transformation in heavy equipment engineering learning can be done by using digital media so that learning can be transformed digitally. The transformation uses virtual reality to simulate practical learning. Although it can improve student understanding, virtual reality transformation can only partially replace the role of conventional learning because some competencies must be taught directly. Digital transformation in heavy equipment engineering learning at SMK N 1 Semarang is carried out due to the demands of environmental conditions. Transformation is carried out on media and learning processes that have been combined with digital media. Based on the study of virtual reality media, the learning application of virtual reality media can improve learning outcomes, motivate students to learn, and present a pleasant and not boring learning atmosphere. The results of this study have important implications for the development of engineering education. The use of VR can be considered as an approach that can improve the quality and effectiveness of learning heavy equipment engineering by providing a more authentic and involved experience for students. Although this research shows clear benefits of using VR in heavy equipment engineering learning, there are still challenges that need to be overcome, such as the limitations of the technology and its integration into the curriculum. However, with the development of technology and commitment to improving engineering education, the use of VR has great potential to enrich the learning experience in the future.

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