Investigating the Adoption of Augmented Reality for Vocational Student Engineering Materials in Hybrid Learning

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ABSTRACT

Education in Indonesia has experienced developments related to the use of technology. Learning on personal computers (PC) and smartphone technology devices is common, and it is also referred to as "hybrid learning." However, when researchers conducted a survey of SMK students in Surakarta, even though they had used personal computers or gadgets, they only used a few media software programs to study engineering material. Seeing this phenomenon, researchers want to identify students' needs for media software, namely mobile augmented reality. This identification aims to provide a critical initial analysis of the need for mobile augmented reality learning media software that is connected to a smartphone for engineering learning for SMK students. The research samples involved were students of SMK N 2 Surakarta and SMK N 5 Surakarta. Using questionnaires, field observations, and interviews as data collection techniques. The data obtained were analyzed descriptively. Define part of the 4D research model using the research method, and the research results show that SMK students in Surakarta require mobile augmented reality media in learning engineering material if hybrid learning is used.

Keywords: Augmented Reality, E-Learning Media, Hybrid Learning, Mobile Learning, Vocational Students
INTRODUCTION

The era of the industrial revolution 4.0 encouraged massive technological developments in various fields, including education. Technology is an important requirement in the field of education. According to AECT (2018), educational technology aims to facilitate learning so that it is interesting, efficient, effective, and increase performance. The Covid-19 pandemic forced everything to move online. Based on Circular Letter Number 4 of 2020 (Kemdikbud, 2020) on the Implementation of Education Policy in the Emergency Period of the Spread of Corona Virus Disease (Covid-19), the learning system is implemented to use a personal computer (PC) or other device connected to an internet network connection. According to this, teachers are forced to use hybrid or distance learning technology. This forces teachers to use instructional media technology for distance learning or hybrid learning. According to the Minister of Education and Culture of the Republic of Indonesia's report on the Implementation of Education Policy in the Emergency Period of the Spread of Corona Virus Disease (Covid-19) (Kemdikbud, 2020), the learning system is carried out using a personal computer (PC) or other device connected to an internet network connection. This forces educators to use instructional media technology for distance learning or hybrid learning.

A teaching method called hybrid learning mixes online and face-to-face instruction. Technology utilization in hybrid learning will be necessary. The technology used in learning will improve the varied teaching process. In line with the statement of McKnight et al. (2016), that technology in learning also allows students to gain broader and less monotonous knowledge (Meirbekov, Maslova, & Gallyamova, 2022). Of course the use of digital technology in learning requires teacher assistance (Maccallum & Jamieson, 2017). However, there are still many notes for educational practitioners to carry out learning that involves technology (Akçayır & Akçayır, 2017). Digital literacy skills are needed for teachers so that learning runs as it should. In line with Singh et al. (2021) claimed that important online features must be well-implemented to prevent interruptions. The learning experience gained by students when using technology in learning will provide them with broader access to information (Smaldino, Lowther, Mims, & Russel, 2019). However, from the results of previous research students still experience many obstacles to rationalizing abstract concepts in engineering subjects (Milton, Flores, Moore, Taylor, & Burton, 2018). For this reason, innovative learning media are needed during the hybrid learning process, one of these learning media technologies is Mobile Augmented Reality (Sungkur, Panchoo, & Bhoyroo, 2016).

A mobile device can be used to mix two-dimensional and three-dimensional virtual elements into a real environment using a technology called mobile augmented reality. The potential for augmented reality technology in education, particularly in vocational education (Radosavljevic, Radosavljevic, & Grgurovic, 2020). Students belonging to vocational education have their own characteristics, that vocational students in engineering are required to have higher creative and critical thinking than high school students (Arum & Roksa, 2011). In addition, vocational students are prepared to be able to work to meet the needs of the industry after graduation (Thibaut et al., 2018). The characteristics of Mobile AR media, which are capable of displaying abstract concepts into 3D visuals, will greatly assist vocational students in understanding engineering materials (Sırakaya & Sırakaya, 2020). In addition, Augmented Reality is able to display information in the form of images, audio and 3D objects that can be seen and felt by users (Garzón, Kinshuk, Baldiris, Gutiérrez, & Pavón, 2020). The combination of several elements that can be displayed in AR will activate several sensory in students and make them interested (Kaur, Mantri, & Horan, 2020) and increase interest in the subjects being studied (Wang, Lee, & Ju, 2019).
Using mobile devices for education involves more than just providing course materials from a pedagogical perspective. Also, it is necessary to consider the capabilities and features of the mobile device itself. Because mobile devices are currently among the most technologically advanced gadgets and have an increasing number of users, users may use them for learning. Mobile learning also gives consumers the option to get contextualized learning content based on their needs, which can aid users or students in understanding the learning information (McQuiggan, Kosturko, McQuiggan, & Sabourin, 2015). Mobile learning is the fourth revolution in education reform, according to the phenomenon itself (Simarmata et al., 2020). The three primary revolutions in education were the invention of writing, the use of textbooks in schools following the advent of printing presses, and the expansion of mainstream education. The adoption of e-learning technologies, particularly m-Learning, represents the fourth revolution. Mobile learning can facilitate students’ learning in a variety of subjects, including business and information technology (Carreon, Smith, & Rowland, 2020). Observations show that the goal, user skill level, and technical aptitude all affect how well mobile devices are used for learning (Lee, Chen, & Chang, 2016).

Mobile devices, that offer flexibility and the capacity to learn from anywhere at any time, can be particularly useful for implementing hybrid learning. The following are some previous studies on the use of mobile devices in supporting hybrid learning: (1) Online Learning Platform: Mobile learning can be integrated with online learning platforms such as Learning Management System (LMS), which allows students to access courses, assignments, and learning materials from their mobile devices (Gamage, Gamage, & Dehideniya, 2022); (2) Responsive Learning Content: Learning content should be responsive, meaning it can be accessed from mobile devices and adapted to different screen sizes. Responsive content also makes it easier for students to access learning materials from their mobile devices without having to zoom in or out (Bhutto, Soman, & Sungkur, 2017). Learning apps can be built specifically for mobile devices, allowing students to learn anywhere and anytime. These apps can include features such as online tests, exercises, and student progress monitoring (Karabatzaki et al., 2018).

Furthermore, based on data from research by Turhan et al. (2022) that students experienced moderate burnout and fatigue during hybrid learning during the pandemic as much as 55%. Teaching only in the old-fashioned way is wrong for one reason Aindra, Wibawa, & Nurhadi, (2022). In addition, the data obtained from the initial survey by researchers showed that 78% of vocational students in Surakarta experienced a decrease in their interest in learning. From the student's perspective, the learning media used by the teacher during learning is very monotonous and does not vary. Making students easily lose their enthusiasm for learning (Raes, Detienne, Windey, & Depaepe, 2020) during hybrid learning. Based on the facts in the field and the results of previous research, it is necessary to further explore the needs of learning media for vocational students for technical subjects. In this study further investigation will be carried out. To establish what is needed for suitable learning media, both from the perspectives of teachers and students.

LITERATURE REVIEW

According to the definition by the Association of Education Communication Technology, media refers to all useful channels that serve as intermediaries for information delivery. Learning media serves as a tool to provide stimuli for students during the learning process. Robert (1985) states that media encompasses various types of components in the students' environment that can stimulate the learning process. In the context of education, media can be interpreted as a means for teachers to convey knowledge and information to students during the learning process. Using appropriate learning media can effectively deliver information and provide valuable experiences for students. The
research findings by (Grawemeyer et al., 2017) indicate that supported learning experiences during the teaching process have a positive impact on students' learning achievements.

Learning media in the teaching and learning system, according to (Heo & Toomey, 2020), serves the following functions: 1) increasing student motivation; 2) facilitating students' reception of information and course materials; 3) introducing variation in the learning process; and 4) making learning more interactive and extensive. It is essential to emphasize that media's ability as a message channel significantly supports modern learning. Media in the learning process can serve as a tool to transform abstract concepts into concrete representations. For difficult-to-imagine topics, learning media will aid teachers in explaining the material more effectively.

One of the media that can be developed is augmented reality. The capability of augmented reality to visualize 3D objects can be utilized to present objects that students would not otherwise encounter directly, thus providing a more realistic visual experience (Furió, Gonzales-Gancedo, Juan, Seguí, & Costa, 2013). Huang, Chen, and Chou (2016) state that augmented reality has at least five potentials in learning activities: 1) Introduction and observation of 3D objects in learning; 2) Combination of wireless networking and location-based detection supporting ubiquitous learning; 3) Enhancing readiness, willingness, and participation in lessons; 4) Visualizing abstract concepts; 5) Integrating formal and informal learning.

With the appropriate display technology, real and virtual elements can be merged, while specific input devices allow for interaction, and effective integration requires efficient tracking. In broad terms, augmented reality technology requires supportive devices, including display, input devices, tracking, and computer (Carmigniani et al., 2011). The use of these devices is crucial to ensure smooth application and to provide users with a contextualized experience.

**RESEARCH METHOD**

The methods and steps in this study in general use the Define-4D Thiagarajan method. The Define research method is one of the needs analysis methods used to understand user needs and determine the right solution to meet these needs. In this method, researchers seek to understand the needs, wants, and expectations of users in the use of a system or product. Has a structured and methodical process in conducting a requirements analysis. This method helps ensure that researchers can collect data in a structured and systematic way. In addition, it helps researchers to clearly define user needs. This helps in determining the right solution to fulfill those needs. This method involves comprehensive and in-depth data collection from users. This helps the researcher to understand the needs and problems faced by the users in detail. Overall, the Define research method is a very effective and appropriate requirement analysis method to use in product or system development. This method helps researchers to understand user needs clearly and in detail and determine the right solution to meet these needs. For data analysis, research samples, as well as data collection techniques to be used in detail are described as follows:

**Research Methodology**

Based on the relevance of the background and the issues that have been stated, the goal of this research is to examine or determine the necessity for the use of augmented reality as a medium of learning for vocational students. It can be said that the type of research approach that best fits the purpose is qualitative research. Collecting data and information for qualitative research using questionnaires, interviews and field conformity observations (Coolican, 2018). Following data collection, a quantitative descriptive
A statistical test was applied to analyze the data. The research subjects involved were 10 Road and Bridge Construction teachers (N = 10) and 120 vocational school students majoring in building engineering from SMK N 2 Surakarta and SMK N 5 Surakarta. Gender of women and men. In general, the research flow is described in the following diagram:

**Figure 1. Flow of Data Collection**

![Flowchart](image)

**Instrument**

The instrument is a tool used for the data collection process (Creswell & Creswell, 2017). The instruments used in this study were interview instruments, observation instruments and questionnaire instruments. There are several types of questionnaires used, including: (1) questionnaires to study the characteristics of students and the learning media used, (2) in-depth interviews are useful for obtaining more information from students and teachers, (3) observing class activities aims to directly observing the type of media used by the teacher during the learning process.

The instrument used must meet expert validation and due diligence. The feasibility test is reviewed from the results of validity and reliability (Kimberlin & Winterstein, 2008). The results of the instrument reliability test were Sig. 0.745 > 0.3 (r minimum) and the validity test is Sig. 0.831 > 0.177 (r table) so that the instrument is declared valid and reliable. Data collection was carried out in class XI majoring in building engineering in the subject of Road and Bridge Construction.
RESULTS & DISCUSSION

The results of data collection and analysis that have been carried out will be described one by one in detail. Analysis of learning activities is done by observation and interviews. Observations were carried out for 4 meetings about Road and Bridge Construction in class. At the time of observation, the learning process policy was carried out using hybrid learning, namely face-to-face learning was limited with a maximum capacity of 50% of students in class and the rest were studied at home (Raes, Detienne, Windey, & Depaepe, 2020). During the observation, various lists of problems were found. The first problem is that students experience burnout during learning issues.

Figure 2. Learning Activities in Class and at LMS

In addition to students being less active in class and students' ability to answer questions did not meet the teacher's assessment criteria, students were also less enthusiastic. As for exploring students' perspectives by conducting interviews, they speculate that the Road and Bridge Construction subject is a subject that has a long duration at each meeting. In addition, these subjects contain a lot of material. During the interview with the teacher, the teacher himself admitted that he did not know the exact reasons why his students showed many deficiencies. Because so far, the teacher feels that he has carried out his duty to teach the material according to schedule. Based on these two points of view, it can be concluded that students experienced several obstacles while following the lesson. One of the influencing factors is the less interactive classroom environment (Dunn & Kennedy, 2019).

Figure 3. Media Variations Used

PPT and material books are frequently utilized as media. According to the findings of teacher interviews, teachers are accustomed to simply using books and PowerPoints as
learning tools. The use of media that is one way will be difficult to make learning constructive (Orey & Maribe Branch, 2017). The PPT given to students only displays text and images. Learning media that are 2D, students can only see the display displayed by the teacher (Smaldino, Lowther, Mims, & Russel, 2019). Meanwhile, constructive learning is learning that involves student interaction (Turkan, Radkowski, Karabulut-Ilgu, Behzadan, & Chen, 2017). Every month there are 4 x JP (Meeting Hours), so that in 3 months there are 12 meetings. According to the diagram above, subject books account for up to 57% of all learning media usage variations, making them the learning media that is used the most frequently. PPT is another kind of instruction tool that is occasionally utilized, accounting for up to 20% of all learning tools used, along with laptop and cellphone media on occasion.

Based on the literature study, it is necessary to have innovative learning media for learning Road and Bridge Construction. One of the media that can be used is 3D-based digital media. According to Carreon, Smith, and Rowland (2020), one of the interactive learning media, does not require a lot of money, can display real learning, is easily accessible, namely augmented reality media. An instructional innovation is the use of augmented reality for SMK students to learn about the topic of Road and Bridge Construction. While there is still only a minimal variety of media available in schools, according to the results of teacher interviews and surveys. The following are the results of a survey of vocational schoolteachers in Surakarta (N=10):

Table 1. Teacher Survey (N=10)

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you often use learning media to teach?</td>
<td>YES, 76%</td>
</tr>
<tr>
<td>2</td>
<td>What types of learning media do you use most often more than 3?</td>
<td>YES, 36%</td>
</tr>
<tr>
<td>3</td>
<td>Do you feel that the learning media you use are easy for students to understand?</td>
<td>YES, 46%</td>
</tr>
<tr>
<td>4</td>
<td>Do you prefer to teach with static media?</td>
<td>YES, 10%</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, is the learning media that you use effective enough in helping students learn?</td>
<td>YES, 43%</td>
</tr>
<tr>
<td>6</td>
<td>Is there a type of learning media that you would like to teach but are not yet available in schools?</td>
<td>YES, 83%</td>
</tr>
<tr>
<td>7</td>
<td>Are there still many shortcomings of the learning media that you usually use?</td>
<td>YES, 64%</td>
</tr>
<tr>
<td>8</td>
<td>Has the learning media you used helped students understand difficult concepts?</td>
<td>YES, 20%</td>
</tr>
<tr>
<td>9</td>
<td>Are there special features in the learning media that you use to help teach?</td>
<td>YES, 22%</td>
</tr>
<tr>
<td>10</td>
<td>Do you need support from the school in obtaining better and more complete learning media?</td>
<td>YES, 100%</td>
</tr>
</tbody>
</table>

According to table 1, that illustrates the results of a survey of students, teachers often employ no more than three forms of learning material. Even though they often use learning media for teaching, teachers feel that the media is not effective in helping students to understand abstract concepts. Teachers do not know the features in the media that are often used. The features available in the media are very useful for interactively exploring information (Loveland, 2020). Teachers also need school support in providing innovative learning media. That according previous research findings
(Maccallum & Jamieson, 2017), organizational support or academic institutions have an impact in the usage of new media in learning. The needs from the student's point of view are presented in the following table:

**Table 2. Student Surveys (N=120)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you often use learning media to study?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Do you prefer media in the form of text or images?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Do you feel that the media used today is effective enough to help understand the material?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Are there other media that you would like to know about being used in learning?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, is the learning media that you use effective enough in helping students learn?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Is there a type of learning media that you would like to teach but are not yet available in schools?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Do you feel that using media helps you to be more active in learning?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Do you feel that the media used today is less interesting or boring?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Is there any media that you want to use in learning that has never been used before?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Do you feel that the media used today is safe enough to be used in learning?</td>
<td></td>
</tr>
</tbody>
</table>

SMK students in Surakarta often use learning media when studying. However, the preferred media is media that displays lots of images. Media accompanied by pictures and illustrations will more easily attract students' attention (Smaldino, Lowther, Mims, & Russel, 2019). However, the media that is currently often used by students has not been effective in helping students to understand abstract concepts. Because these constraints become one of the factors that hinder students from being active in learning. Students at Surakarta Vocational High School are mostly bored with the existing media variations and want to learn media that is innovative and different from those that already exist. Overall, it can be said that students want learning media that is fun, flexible, easily accessible, and helps them learn more effectively and efficiently.

In order for the chosen learning media to satisfy students' learning needs, it is necessary to consider the characteristics of the students (Heo & Toomey, 2020). At SMK N 2 Surakarta and SMK N 5 Surakarta, the average age of class XI students is 16 to 17. In the age range of 16-17 years, according to Piaget, it enters the formal operational period (Flavell & Piaget, 1967). Furthermore, the language used in everyday learning is Indonesian. As for the character of students in SMK based on the results of observations and interviews with counseling teachers that have been carried out, namely having a strong will, friendly, open, and able to be responsible. It is supported by the results of research by Lucas, Spencer, & Claxton (2012) that the characteristics of students in vocational schools, both male and female, in terms of emotional stability, extraversion (good at speaking and socializing), openness to experience, sensitivity to conscience and responsibility are quite high. For both female and male students there is no significant difference in terms of their learning outcomes. Data on learning outcomes were obtained
by researchers from the process of documenting students’ daily test scores on these subjects.

The results of the analysis regarding students’ attitudes towards the Road and Bridge Construction subject, most of them have an open attitude with the acquisition of questionnaire data of 76% of the total students. Students are open to any media used in learning and 100% of students use smartphones at school. With a variety of smartphone operating systems that are used mostly Android. The number of Android users due to several advantages it has. Android has a variety of sophisticated features, is easy to use and can be applied to mobile devices that have a small management space (Garg & Baliyan, 2021). The following is a questionnaire data for students’ smartphone operating system variations:

Figure 4. Variations in Smartphone Operating Systems

According to the research that has been done and the documents, the Core Competencies (KI) and Basic Competencies (KD) in Road and Bridge Construction subjects are 21 KI & KD. The KI & KD, which contains the most material and requires a deeper understanding from students is KD 3.5: Understanding Bridge Specifications. In the basic competence of bridge specification materials, the materials loaded include: concrete, prestressed concrete, reinforcing steel, structural steel, wood, pile foundations, drilled foundations, pit foundations, cement mortar mix, stone masonry, empty masonry, expansion joints, bridge foundations, backrests, bridge nameplates, demolition of structures. Basic competence of bridge specifications in Road and Bridge Construction subjects including productive subjects in Vocational High Schools. This means that these subjects aim to provide specific skills and work competencies for students. The results of the next analysis are the elaboration of KD 3.5 bridge specification material. The description is presented in the form of Points of Competency Achievement Indicators which can be seen in the following table:

Table 3. Student Competency Indicators

<table>
<thead>
<tr>
<th>No.</th>
<th>Level</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5.1</td>
<td>C2</td>
<td>Explain the definition of bridge specifications from various sources.</td>
</tr>
<tr>
<td>3.5.2</td>
<td>C2</td>
<td>Explain the various types of bridge classification.</td>
</tr>
<tr>
<td>3.5.3</td>
<td>C2</td>
<td>Describe the design of the bridge class</td>
</tr>
<tr>
<td>3.5.4</td>
<td>C2</td>
<td>Describe the parts of the bridge.</td>
</tr>
<tr>
<td>3.5.5</td>
<td>C2</td>
<td>Describe the cross section of the bridge.</td>
</tr>
<tr>
<td>3.5.6</td>
<td>C2</td>
<td>Explain bridge design</td>
</tr>
<tr>
<td>3.5.7</td>
<td>C4</td>
<td>Analyze bridge specifications from various sources.</td>
</tr>
</tbody>
</table>
The student competency indicators above show that the material taught in Road and Bridge Construction is complex. The delivery of material that is complex and full of abstract concepts requires effective and efficient learning media to help students’ understanding (Clark, 1994). The presence of augmented reality to be adopted into learning Road and Bridge Construction techniques received positive responses from teachers and students of SMK in Surakarta. Augmented Reality is a new media that they know. For them, the 3D concept that will be displayed in Augmented Reality can help the process of understanding the material more effectively. AR media can be developed according to the results of the analysis that has been done. Augmented Reality media can support constructivist learning theory (Cheng & Tsai, 2013), which suggests that students learn through direct experience and interaction with the surrounding environment. The use of augmented reality as a learning media can facilitate direct experience and student interaction with learning materials, so that it can accelerate the process of cognitive understanding and development.

Where the results of the analysis in outline are media users in the age range of 16-17 years old, already classified as children in the operational period, most users of Android operating system smartphones, technical subjects full of abstract concepts and demands for student skill achievements which include many, teachers need interesting media for teaching, students need media that can help them understand difficult concepts. Of course, the media was developed without making it difficult for users to operate and pay a certain amount of money. Existing media should really help solve the problem.

CONCLUSION

The findings and discussion indicate that appropriate use of instructional media can enhance the effectiveness of the learning process. These media aid in engaging students and promoting better comprehension and retention of information. Furthermore, incorporating diverse and captivating media can increase students’ motivation to learn. Hence, it is crucial to consider the use of suitable learning media in the modern digital era, with the caveat that the choice of media should align with students' characteristics and the subject matter for optimal outcomes.

The potential benefits of using augmented reality as a learning tool can be maximized through proper education of teachers and students on its use. Augmented reality can be tailored to meet specific requirements, but it is important to ensure that the chosen technology is well-suited to the learning material to achieve desired learning objectives. Based on the needs assessment, Mobile Augmented Reality media appears to be a valuable learning tool for the specification of bridges and road construction. Augmented reality technology needs to be further developed and integrated into learning settings. This insight can guide augmented reality application developers in creating more effective applications that support student learning, and teachers in designing more engaging and interactive lessons that enhance learning quality in schools.

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DECLARATION OF CONFLICTING INTERESTS
The authors declare that they have no conflicting interests regarding the publication of this manuscript.

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